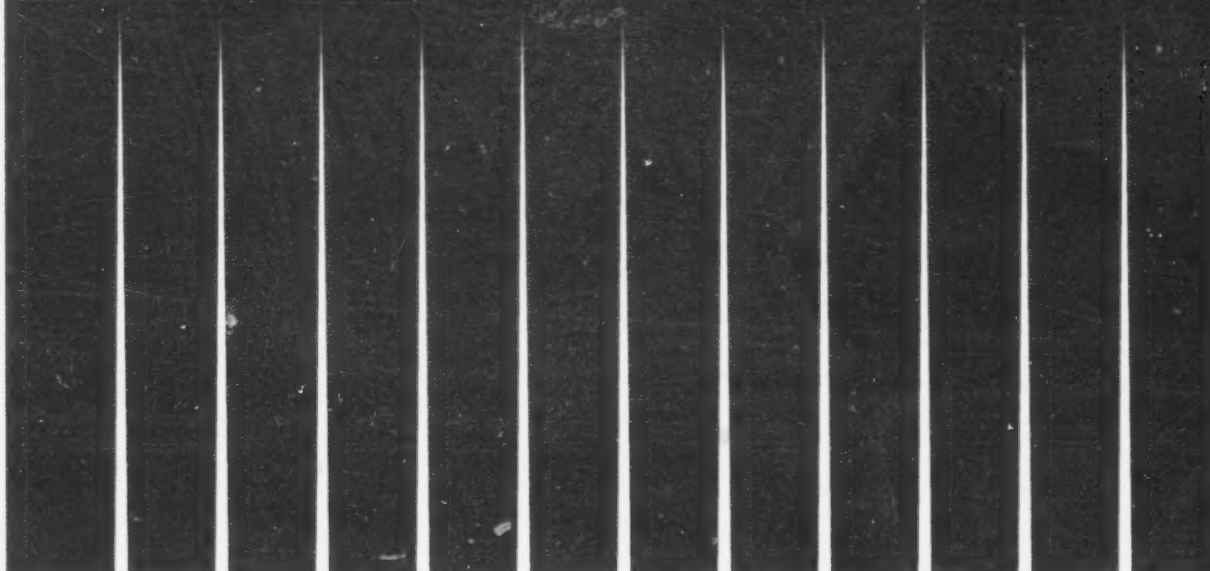
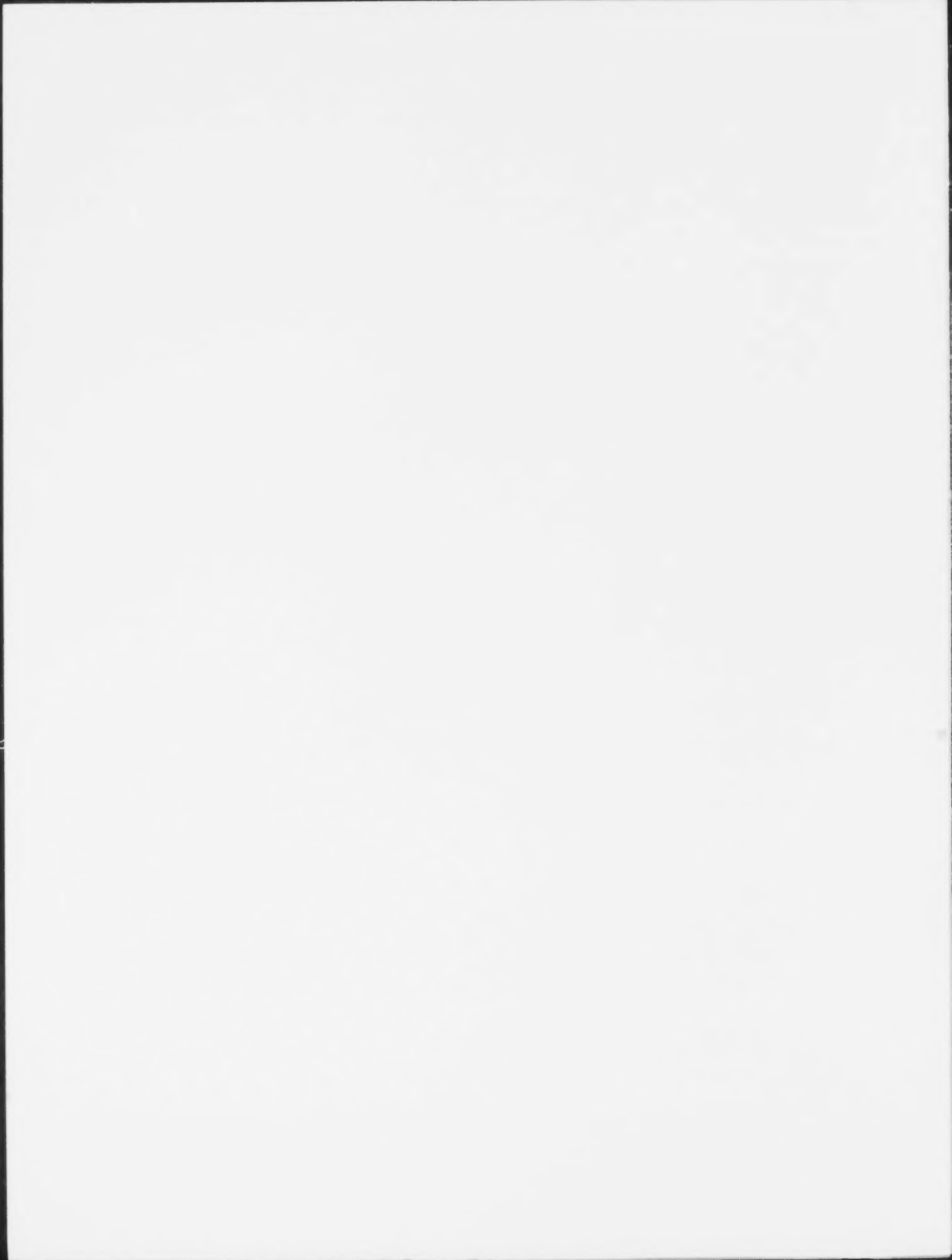


BENEFICIAL MANAGEMENT PRACTICES

Environmental Manual
for Crop Producers in Alberta





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Environmental Manual for Crop Producers in Alberta



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

Prairie Farm Rehabilitation
Administration

Administration du retablisement
agricole des Prairies

Alberta
AGRICULTURE, FOOD AND
RURAL DEVELOPMENT

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Disclaimer

The primary purpose of the *Beneficial Management Practices: Environmental Manual for Crop Producers in Alberta* is to assist crop producers in selecting and implementing beneficial management practices.

While the authors have taken every effort to ensure the accuracy and completeness of the *Manual*, the *Manual* should not be considered the final word on the areas of law and practice that it covers. Producers should seek the advice of appropriate professionals and experts as their individual situations may differ from those set out in the *Manual*.

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Foreword

Beneficial Environmental Practices for Crop Producers in Alberta

This manual was prepared for Alberta crop producers to create greater understanding of beneficial environmental practices for crop production. It was developed through the cooperation of government, industry, and interested stakeholders. Information presented in this manual is based on the best available research data and years of experience. The manual provides a range of management options so producers can choose those alternatives best suited to their own operation.

This manual is a living document. It will be updated regularly to incorporate changes in regulations and new information on environmentally sound practices.

Developed by:

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Canadian Seed Growers Association, Alberta Branch
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Environmental Law Centre
Prairie Oat Growers Association
Potato Growers of Alberta
Reduced Tillage Linkages

Note:

– throughout this manual, this symbol identifies where additional information is available.



CHAPTER 1.0

Introduction

This chapter discusses **beneficial management practices** and **environmental stewardship**. Beneficial management practices are practices that benefit the environment while being practical for producers to meet or exceed legal requirements.

1.1 Purpose

This manual has been prepared for you, an Alberta crop producer, to provide information about a wide range of **beneficial management practices** (BMPs) suited to crop production in Alberta. BMPs are practices that benefit the environment while being practical for producers to meet or exceed legal requirements.

BMPs improve a farm's soil, water, air and wildlife habitat resources, and so contribute to the farm's overall sustainability and to the farm family's quality of life. BMPs also contribute to the environmental health of the surrounding landscape and communities.

Chapter 2 describes the environmental considerations related to crop production. Chapters 3 to 7 discuss farming practices that reduce or prevent impacts on soil, water, air and wildlife habitat. Chapters 8 and 9 describe community and legal considerations in crop production. Chapter 10 is a glossary of terms used in the manual; words defined in the glossary are highlighted in bold when they first appear in the main text of the manual. The manual provides both metric and imperial units in most instances; information on converting units is provided at the end of the manual.

This manual is aimed at producers who are striving for excellence in environmental stewardship. Therefore, many of the practices described in Chapters 3 to 7 go beyond the basic legal requirements, outlined in Chapter 9, that Alberta producers must meet.



Beneficial management practices contribute to a healthy landscape.

Courtesy of AAFRD

Each farm is unique. Not all of the practices in the manual are suited to every cropping operation. You will need to consider the various options, choose those best suited to your needs, and adapt them to the specific conditions on your farm.

If you are an experienced crop producer, this manual can help you enhance your stewardship of the environment. If you do not have a strong knowledge of crop production, you will need to consult other information sources – such as experienced farmers in your area, college and university courses, other publications, and professional agronomists – because all aspects of farm management need be taken into account when deciding on the best practices for your farm.

1.2 Background

Most agricultural producers in Alberta value the environment and feel strongly about their role as stewards of the environment. They also understand that, for their farm to remain productive and for Alberta's agricultural industry to be competitive on world markets, they need to safeguard environmental quality.

The competition for land and water resources has increased in recent decades as Alberta's population and economy have grown. This trend makes it increasingly important for everyone, including farmers, to manage these resources wisely.

Implementing BMPs suited to your farm is an important component in building and maintaining an operation that is economically sound as well as socially and environmentally responsible.



⇒ Competition for land and water resources makes it important to manage these resources wisely.

Courtesy of AAFRD



CHAPTER 2.0

Environmental Considerations

This chapter describes the potential environmental effects of crop production on soil, water, air and wildlife. Subsequent chapters will describe beneficial management practices to address these issues.

Soils consist of four major components including organic matter, mineral particles, water and air (Figure 2.1).

2.1 Soil Organic Matter

Soil organic matter is composed primarily of plant residues in various stages of decomposition. It accumulates when the return or addition of plant residues is greater than their rate of decomposition by microbes. Organic matter occurs naturally in all Alberta soils, though the amount varies considerably from place to place (Table 2.1).

TABLE 2.1

SOIL ORGANIC MATTER LEVELS IN CULTIVATED SOILS IN ALBERTA

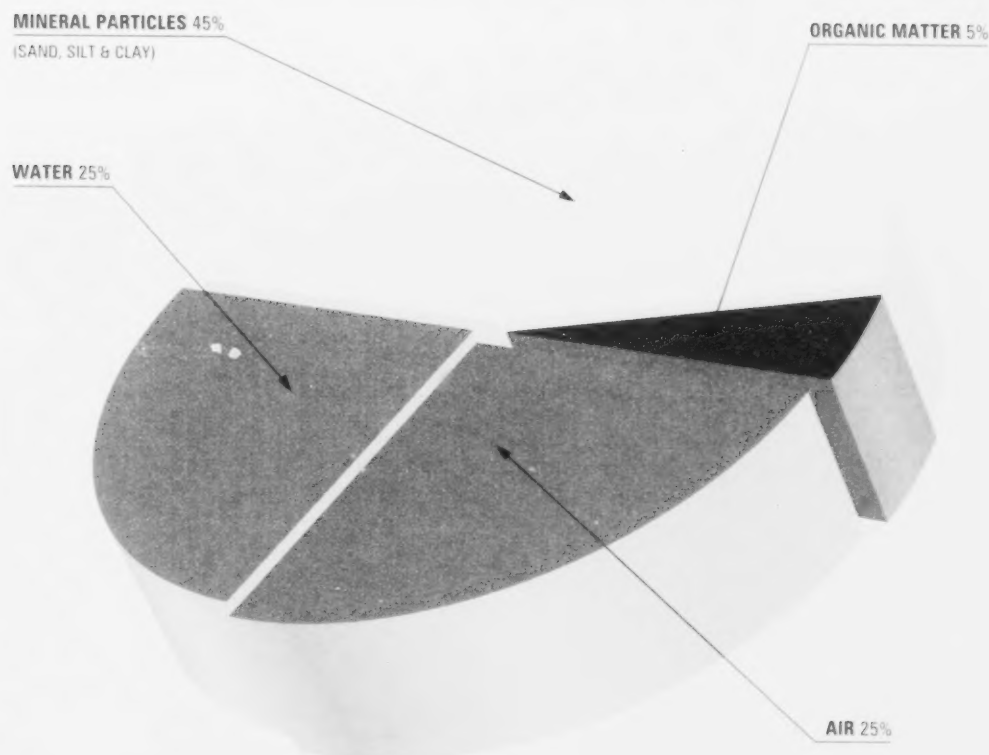
ECOREGION	SOIL ZONE	PERCENT SOIL ORGANIC MATTER
Peace Lowland	Dark Gray	5 - 7
Boreal Transition	Gray	4 - 6
Fescue Grassland, Aspen Parkland	Black	5 - 7
Moist Mixed Grasslands	Dark Brown	4 - 5
Mixed Grasslands	Brown	1 - 3

*Adapted from: Alberta Agriculture, Food and Rural Development, 2001: AESA Soil Quality Benchmarks Study.
Alberta Agriculture, Food and Rural Development, AESA Factsheet FS2001-15Q*

Soil organic matter improves the physical and chemical properties of soil by:

- ▶ holding individual soil particles together in soil aggregates, thereby reducing the risk of soil erosion;
- ▶ improving soil structure, workability, aeration, water penetration and water-holding capacity;
- ▶ reducing the risk of crusting of the soil surface, which can reduce or prevent seedling emergence; and
- ▶ storing and supplying nutrients essential to plants and soil microorganisms.

FIGURE 2.1

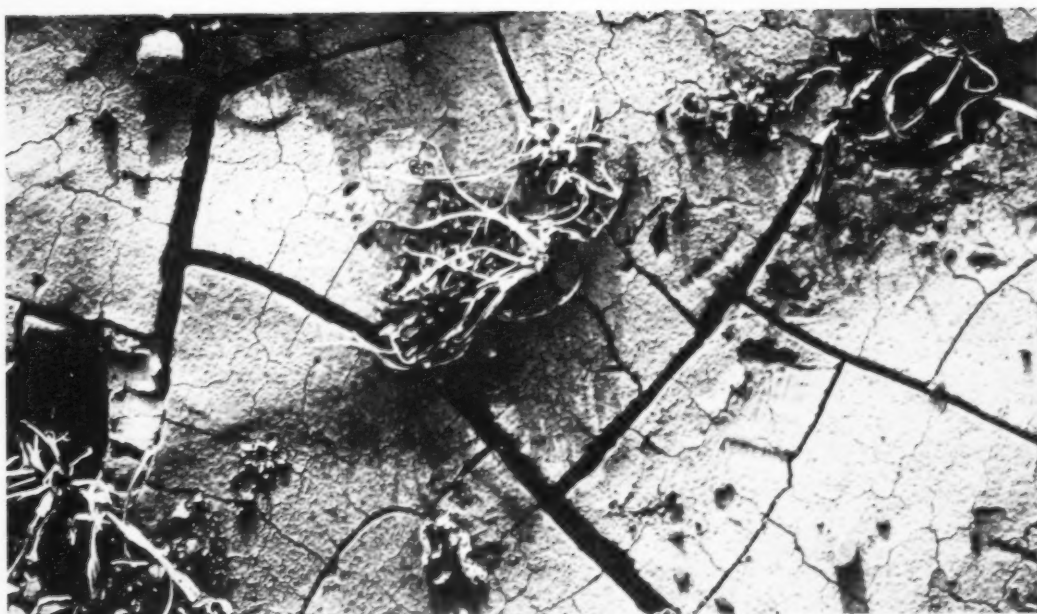
COMPOSITION OF SOIL

*Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1997
Best Management Practices: Soil Management, Agriculture and Agri-Food Canada and Ontario Ministry of
Agriculture and Food, p. 7*

Loss of soil organic matter results in reduced fertility, poor water-holding capacity, greater risk of erosion, and lower crop yields.

Factors affecting organic matter content:

- ▶ Organic matter tends to accumulate faster in cooler, wetter areas, and to decompose faster in warmer, drier areas.
- ▶ Crop rotations with more perennial forages, especially legumes, result in higher organic matter levels because these crops leave more residues than other crops. (Crop residues are the plant material remaining after harvest, including leaves, straw and roots.)
- ▶ Greater application of fertilizers, including manure, increases organic matter levels by increasing crop production and therefore the amount of crop residues.
- ▶ Tillage increases aeration, leading to faster decomposition of soil organic matter by soil microbes.
- ▶ Summerfallow decreases soil organic matter content over time because less plant residues are returned to the soil.
- ▶ Practices that leave the soil prone to erosion (see Section 2.2) increase the risk of organic matter loss by erosion.



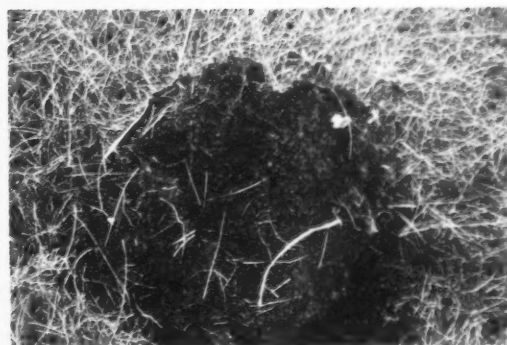
⇒ Soil crusting can reduce seedling emergence.

Courtesy of AAFRD

Cultivated



No-till



Sod

⇒ Aggregation is best under sod or no-till. Annual cultivation hastens decomposition of organic matter.

Courtesy of AAFRD



Legumes protect soil and add organic matter.

Courtesy of Roger Bryan

For more information, see *The Health of Our Soils* (Agriculture and Agri-Food Canada (AAFC)), *Soil Organic Matter* (Alberta Agriculture, Food and Rural Development (AAFRD)), and *Environmental Sustainability of Canadian Agriculture: Report of the Agri-Environmental Indicator Project* (AAFC).

2.2 Soil Erosion

Soil erosion is the removal of soil by wind, water or tillage. Erosion removes the topsoil, the most productive portion of the soil, reducing levels of organic matter and nutrients, and resulting in lower productivity. Eroded soil particles can reduce water quality and air quality. As well, eroded soil can include soil-attached pesticides and nutrients that further decrease water and air quality (Sections 2.6 and 2.7).

For more information on soil erosion, see *The Health of Our Soils* (AAFC), *An Introduction to Water Erosion Control* (AAFRD), and *An Introduction to Wind Erosion Control* (AAFRD).



⇒ Bare soils are vulnerable to erosion.

Courtesy of AAFRD



⇒ Crop residue protects the soil.

Courtesy of AAFRD

2.2.1 Water Erosion

Water running over the surface of the soil, called runoff, can pick up, carry and deposit soil particles. Water erosion removes topsoil, reducing soil quality and contributing to lower crop yields. If the eroded particles are carried to a water body, they can degrade water quality and harm the aquatic habitat.



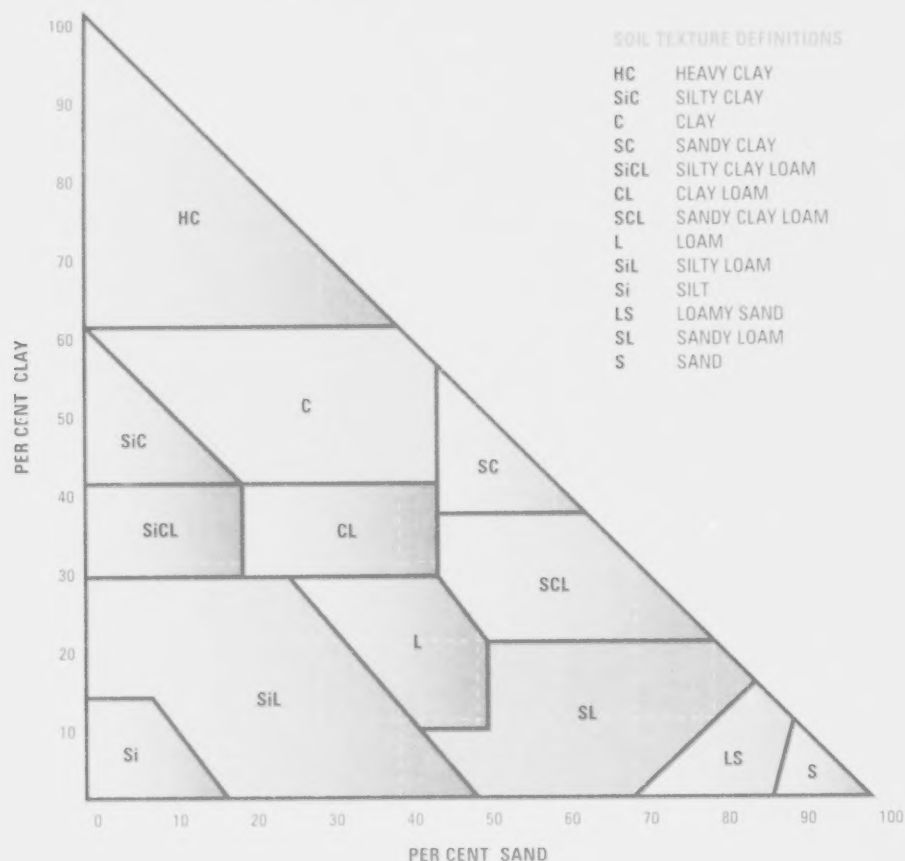
Water erosion removes topsoil, reducing soil quality.

Courtesy of AAFRD

Factors affecting the risk of water erosion:

- ▶ Soil covered by plants or plant residues is less susceptible to water erosion than bare soil. Growing plants and a crop residue cover absorb the energy of raindrops and slow the flow of runoff, reducing the risk of erosion. Roots hold soil in place and contribute organic matter, which further stabilizes the soil.
- ▶ The greater the amount and intensity of snowmelt or rainfall, the greater the risk of water erosion.
- ▶ Steep and/or long, uninterrupted slopes are especially prone to erosion because water can pick up speed as it travels downslope.
- ▶ Fine- to medium-textured soils (Figure 2.2), especially clays and silts low in organic matter, are very prone to water erosion.
- ▶ Sometimes clayey and silty soils can be prone to crusting. Crusting reduces water infiltration (the movement of water into the ground). Less infiltration means more runoff and a greater risk of water erosion.
- ▶ Soils with a shallow, impermeable layer (hardpan layer) are more prone to erosion because this layer limits infiltration deeper into the soil.
- ▶ Tillage leaves the soil prone to water erosion by decreasing the size and stability of aggregates, thus decreasing infiltration, and by burying the crop residue cover.

FIGURE 2.2

SOIL TEXTURE

Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food: 1997. Best Management Practices. Soil Management. Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food. p. 8.

2.2.2 Wind Erosion

Soil particles can be picked up, carried and deposited by the wind. Wind erosion removes the topsoil, resulting in less productive soil and lower crop yields. It tends to carry away the smaller particles leaving the larger particles behind. The visible effects of wind erosion include soil deposited along fence lines and in ditches, blackened snowdrifts and eroded knolls.



➡ Visible effects of wind erosion include soil deposited along fence lines and in ditches.

Courtesy of AAFC

Factors affecting the risk of wind erosion:

- ✦ Smaller soil particles are easier to erode than larger ones.
- ✦ Organic matter helps hold soil particles together in soil aggregates; these aggregates are harder for the wind to move than small individual soil particles.
- ✦ A cover of plants or plant residues prevents wind erosion.
- ✦ High wind speeds and persistent winds have more erosive power.
- ✦ Wind barriers, such as shelterbelts and wooded areas, reduce wind speeds and the risk of wind erosion (see section 3.3.3).
- ✦ Dry soils are more susceptible to wind erosion.
- ✦ Tillage leaves the soil prone to wind erosion by burying crop residues, drying out the soil, decreasing soil organic matter and decreasing soil aggregate size.



➡ Shelterbelts reduce wind erosion.

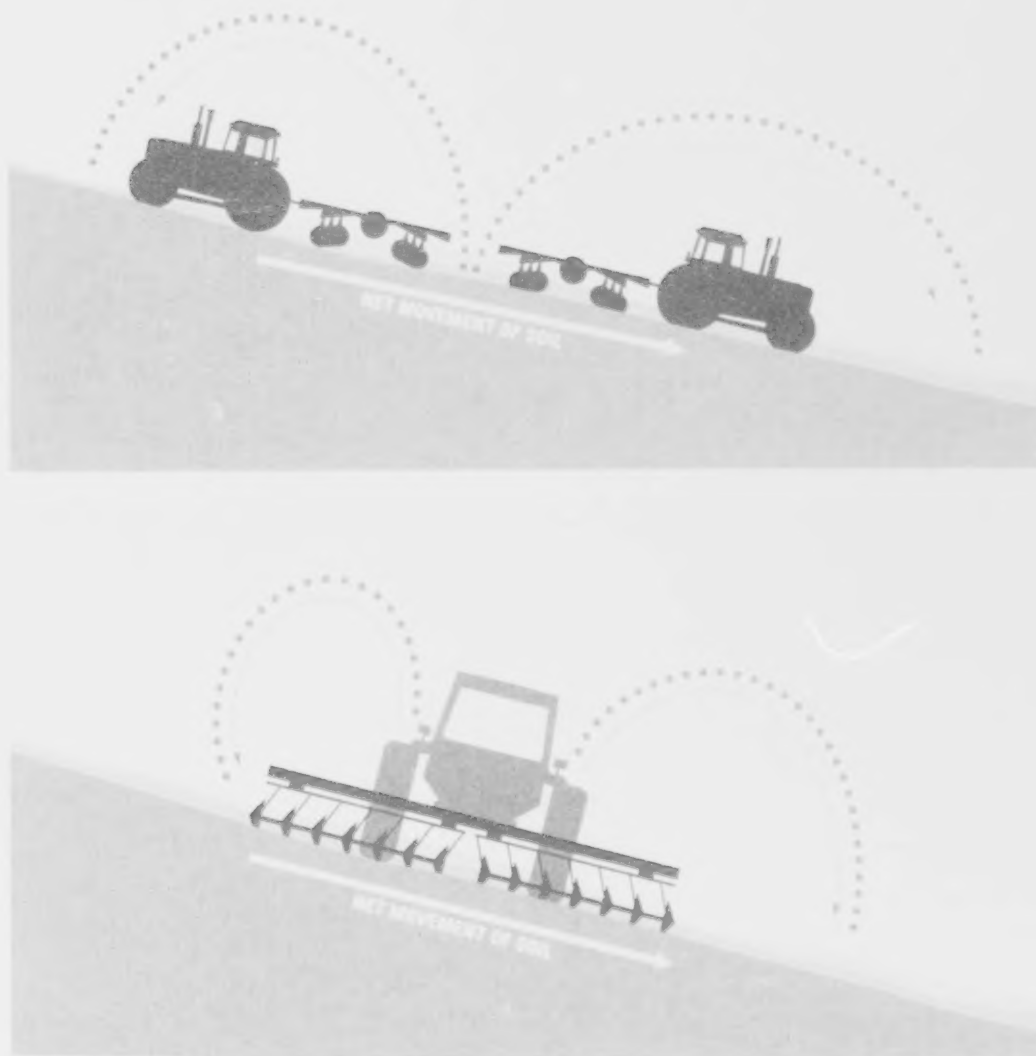
Courtesy of Agriculture and Agri-Food Canada - PFRA

2.2.3 Tillage Erosion

Tillage erosion is the downslope movement of soil by gravity with tillage operations (Figure 2.3). Tillage erosion increases with more tillage passes and greater tillage intensity. It redistributes soil within the field, resulting in topsoil losses on hills and knolls, and accumulations in low areas.

FIGURE 2.3

TILLAGE EROSION



Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food: 1997, *Best Management Practices: Soil Management*, Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, p. 46-47.

Factors affecting the risk of tillage erosion:

- More tillage passes and more intense tillage increase the risk of tillage erosion.
- Use of tillage and seeding implements that cause very little soil disturbance reduces the risk of tillage erosion.
- The risk of tillage erosion is greater on steeper slopes.

For information about results from soil erosion research, see the CAESA Soil Quality Program Research Factsheets (<http://www.agric.gov.ab.ca/navigation/sustain/research/index.html>)

2.3 Soil Salinity

Saline soils contain excess soluble salts in the root zone. High salt concentrations limit the plant root's ability to take up water and nutrients, which restricts crop growth and reduces yields.



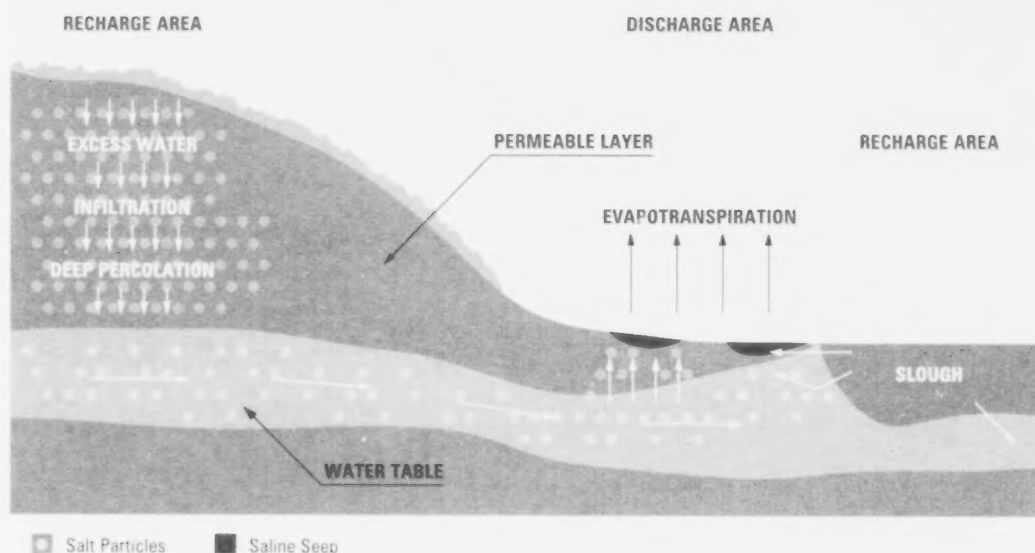
➡ Saline seeps can form where salty groundwater discharges.

Courtesy of AAFC

In Alberta, salts occur naturally in many bedrock deposits and in some deposits on top of the bedrock. Groundwater flowing through these deposits dissolves and transports the salts. Under certain conditions, groundwater discharges at the soil surface. When the water evaporates, the salts are left behind. Over time, the salts accumulate in the groundwater discharge area, forming a saline seep (Figure 2.4). A white salt crust forms where the salt concentration is very high. Only salt-tolerant plants grow in these visibly saline areas (see Table 2.2). The land around the visibly saline area often has saline subsoils, which can lower crop yields.

A saline seep is fed by one or more recharge areas. In a recharge area, water in excess of the soil's water-holding capacity moves below the root zone. This movement raises the local water table, causing the groundwater to flow downslope. Groundwater flows through the subsoil or bedrock, and dissolves and transports salts in the soil. Eventually, the groundwater discharges near or at the soil surface and a seep gradually forms.

FIGURE 2.4

GENERALIZED SALINE SEEP FORMATION

Adapted from: Wentz, D. 2000. *Dryland Saline Seeps: Types and Causes*. Agriculture, Food and Rural Development. Agdex FS518-12

Soil salinity can be measured by electrical conductivity (EC), a measurement of the flow of electricity through a material, such as water or a soil solution. The more salts in the soil sample, the greater its electrical conductivity. EC measurements are usually expressed in deciSiemens per metre (dS/m).

Other Types of Salt-Affected Soils

Saline soils are one type of salt-affected soil. The two other types are:

- ▶ sodic soils, which are affected by too much sodium, and
- ▶ saline-sodic soils, which are affected by an excess of both soluble salts and sodium.

Some practices suited to saline soils can be used for saline-sodic soils. Sodic soils, however, require different management than saline soils. Sodic soils have restricted water movement, are easy to get stuck in when wet, form lumpy seed beds and often have unfavourable pH for crop growth.

People sometimes refer to both saline soils and sodic soils as 'alkali soils', an outdated term used to describe soils with sufficient sodium levels affecting crop growth. To add to the confusion, people sometimes mix up alkaline (high pH) soils with alkali soils. The result can be a misunderstanding of the actual soil condition and use of unsuitable management practices.

If you suspect that you have salt-affected soils, collect samples from the affected area, have them analyzed by a laboratory, and contact a soil specialist to interpret the results.

TABLE 2.2

SALT TOLERANCE OF PLANTS

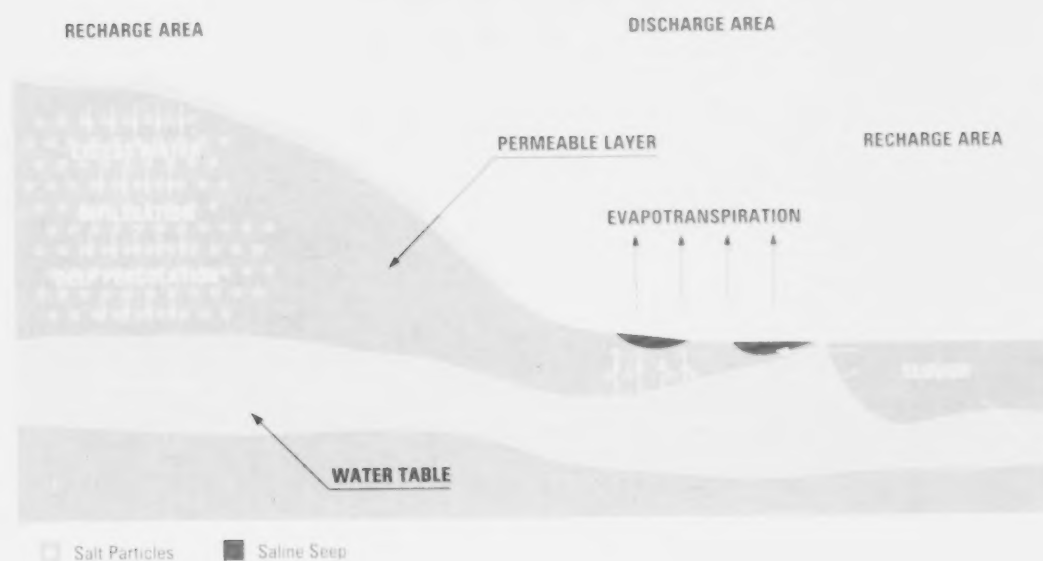
SALT TOLERANCE	EC (dS/m)	FIELD CROPS	FORAGES	VEGETABLES
Very high	20		beardless wildrye Fulks altai grass Levonns alkaligrass alkali sucatan	
High	16	kochia sugar beets	altai wildrye tall wheat grass Russian wildrye slender wheat grass	
	8	6-row barley safflower sunflower 2-row barley fall rye winter wheat spring wheat	birdsfoot trefoil sweetclover alfalfa brome grass	garden beets asparagus spinach
Moderate	4	oats yellow mustard meadow fescue flax canola corn	crested wheat grass intermediate wheat grass reed canary grass	tomatoes broccoli cabbage
Low		timothy peas field beans	white Dutch clover alsike clover red clover	sweet corn potatoes carrots onions strawberries peas beans

Adapted from: Wentz, D. 2001. *Salt Tolerance of Plants*. Alberta Agriculture, Food and Rural Development Agdex FS518-17.

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GENERALIZED SALINE SEEP FORMATION



Adapted from: (1994) by J. R. Coyne, *Soils: A Practical Guide to Soil Science*, 2nd Edition, CRC Press, Inc., Boca Raton, FL, USA.

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TABLE 2.2

SALT TOLERANCE OF PLANTS

SALT TOLERANCE	CEILING	FIELD CROPS	FORAGE	VEGETABLES
Very high	20		beardless wildrye Fulks altai grass Levonns alkaligrass alkali succatan	
High	16	kochia sugar beets	altai wildrye tall wheat grass Russian wildrye slender wheat grass	
	8	6-row barley safflower sunflower 2-row barley fall rye winter wheat spring wheat	birdfoot trefoil sweetclover alfalfa bromegrass	garden beets asparagus spinach
Moderate		oats yellow mustard meadow fescue flax canola corn	crested wheat grass intermediate wheat grass reed canary grass	tomatoes broccoli cabbage
	4			sweet corn potatoes
Low		timothy peas field beans	white Dutch clover alsike clover red clover	carrots onions strawberries peas beans

Adapted from: Wheat '02, 2001, *Soil Response of Wheat: Science and Practice*, by Gary and Rosemary Peterson, Oregon State University.

Factors affecting the formation of saline seeps:

- ▶ Generally, recharge areas occur in upper slope positions, while discharge areas occur in lower slope positions.
- ▶ Periods of high precipitation and irrigation canal seepage can increase the risk of seep formation.
- ▶ Growing high-moisture-use crops, like alfalfa, in recharge areas can reduce the flow of water to discharge areas.
- ▶ Summerfallow in recharge areas can increase the risk of saline seep formation because there are no crops to take up moisture from deep in the soil.

For more information, see *Dryland Saline Seeps: Types and Causes* (AAFRD) and *The Health of Our Soils* (AAFC).

Manure and Salt Accumulation in Soils

Manure contains salt originating from the salt in animal rations. Overapplication of manure can lead to increased levels of salt in soil. See Section 9.1.1 for information about manure application regulations to prevent salt accumulation.

2.4 Soil pH

Soil pH is a measure of acidity or alkalinity in the soil. It is measured on a scale from 1 to 14. The higher the number, the more alkaline the soil; the lower the number, the more acidic. A pH of 7 is considered neutral (neither acidic or alkaline). Most crops in Alberta grow best in soil where pH values range from 6.0 to 7.5. Soil pH can affect crop yields along with the physical, chemical and biological properties of soils.

Soil pH influences the availability of plant nutrients (Figure 2.5). Crop growth, quality and/or yield may be affected if any nutrient is lacking in the soil or is not adequately balanced with other nutrients.

Soil pH can also adversely affect the growth, survival and diversity of soil microorganisms, like nitrogen-fixing bacteria associated with legumes. Some plant species are more acid-tolerant than others (Table 2.3).

TABLE 2.3

CROP TOLERANCE TO ACID SOILS

Non-tolerant Crops: Alfalfa, sweet clover	Tolerate pH 5.5 to 6.0
Moderately Tolerant Crops: Barley, wheat, rapeseed, alsike, red clover, trefoil	Tolerate pH 5.0 to 5.5
Tolerant Crops: Brome, timothy, creeping red fescue, flax, oats	Tolerate pH 4.5 to 5.0

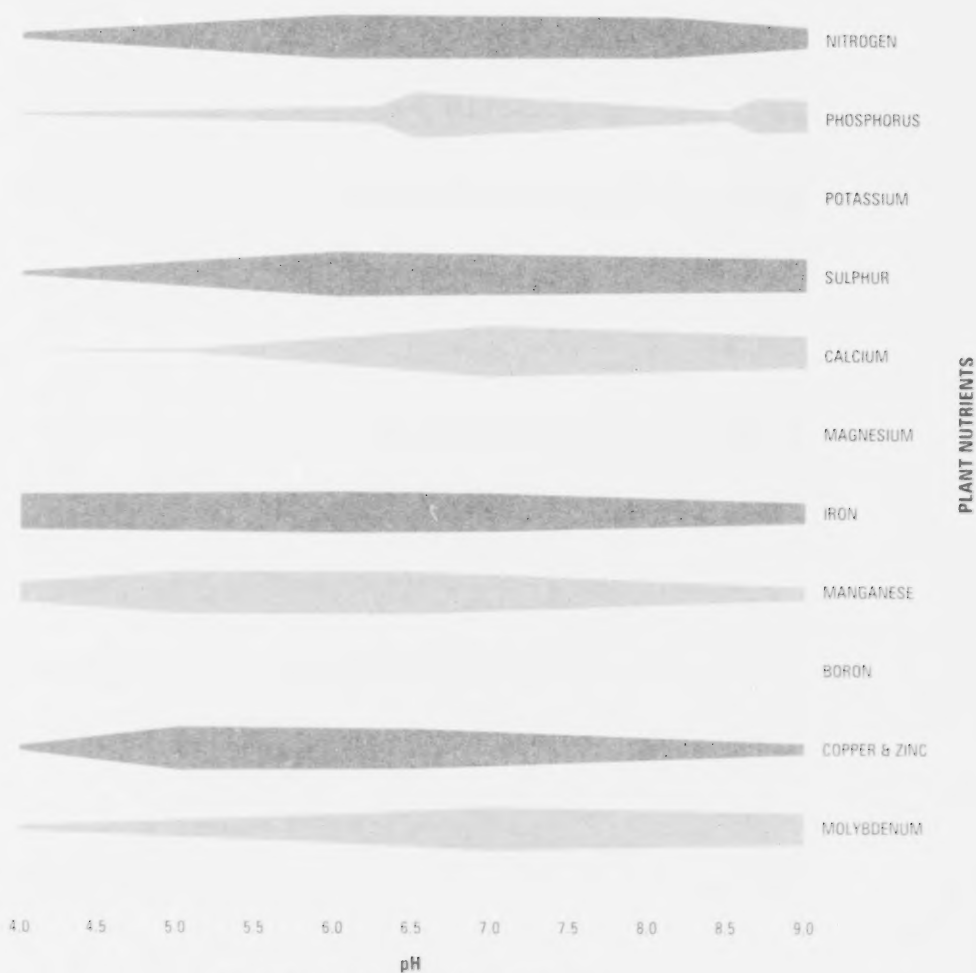
Adapted from: Alberta Agriculture, Food and Rural Development.

Acid soils are most commonly found in central Alberta and in the Peace River region. However, pockets of acid soils can be found in neutral pH areas. The opposite can also occur. Not all soils become acidic. Alberta has naturally high pH soils in the southern dry prairie regions where alkaline (calcareous) subsoils are near the surface.

Factors affecting soil pH:

- ▶ Fertilizer applications (particularly nitrogen-based fertilizers and manure) can increase acidity over the long term.
- ▶ Plants and soil nutrients are in a complex relationship with soil acidity, increasing pH in some cases and decreasing it in others.
- ▶ Peat soils and forest soils are naturally acidic.
- ▶ Acid deposition by rain can increase acidity over the long term.

FIGURE 2.5

NUTRIENT AVAILABILITY AS AFFECTED BY pH

(THE WIDER THE BAR, THE GREATER THE AVAILABILITY)

Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1994.
Best Management Practices: Nutrient Management. Agriculture and Agri-Food Canada and Ontario Ministry of
Agriculture and Food, p. 26

2.5 Soil Compaction

Soil compaction is the reduction of pore space due to equipment and animal traffic. Compaction can develop in any soil type. Because of low porosity, compacted soils are less permeable to air and water. Plant roots have difficulty penetrating the soil, resulting in restricted root growth, reduced nutrient and water uptake, and lower yield potential. Compacted soil is also slower to warm in the spring and more difficult to till.



⇒ Wheel traffic can result in increased compaction, especially on wet soils.

Courtesy of AgTech Centre – AAARD

Factors affecting compaction:

- ▶ Wet soils can be compacted more easily than dry soils.
- ▶ Medium and fine-textured soils and soils low in organic matter are easier to compact.
- ▶ Frequent tillage increases compaction.
- ▶ Frequent wheel traffic and animal traffic increase compaction, especially on wet soils.

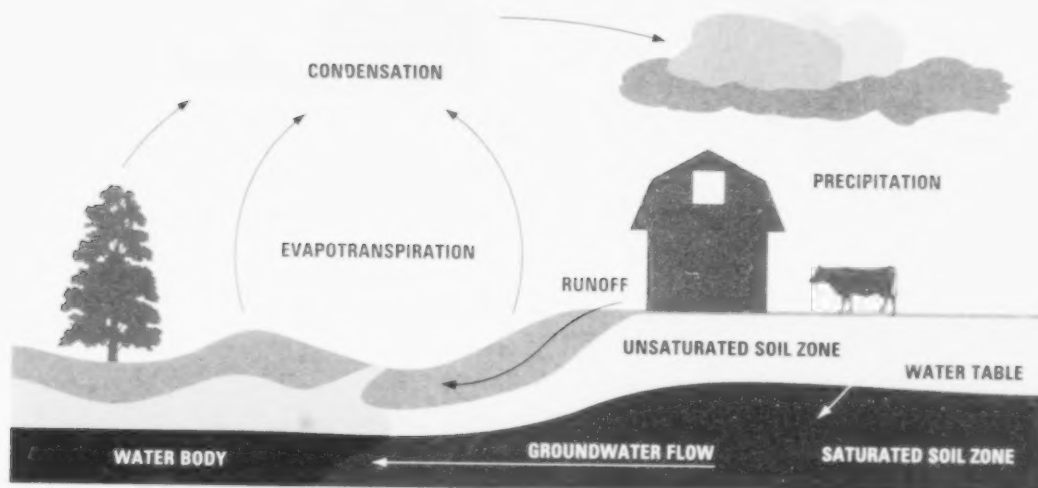
2.6 Water Quality

Crop production can affect water quality if water carries contaminants from fields to surface water or groundwater. Precipitation that falls on the field either as snow or rain can take several paths (Figure 2.6). It can be stored as snow and ice or in puddles, it can flow across the land as overland flow, or it can seep into the ground by infiltration.

Water that seeps into the ground may be stored in an unsaturated zone as soil moisture where it is available for plant use, or it may move down to the groundwater. Under some conditions, water can move laterally in a saturated zone as **interflow**. The term **runoff** includes both overland flow and interflow.

FIGURE 2.6

WATER CYCLE



Adapted from: Adapted from Figure 2.1 in Coote, D.R. and Gregorich, L.J. (eds), 2000. The Health of Our Water: Toward Sustainable Agriculture in Canada. Agriculture and Agri-Food Canada. Publication 2020/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2003.

When water leaves a field by runoff or gravity drainage, it can potentially carry contaminants – such as nutrients, disease-causing organisms, pesticides, sediments, or fuel – to water sources. Surface water sources are most vulnerable to contamination from overland flow and interflow, whereas groundwater sources are most vulnerable to contamination through leaching. Contaminants may be dissolved in water, or they may be attached to soil particles and carried away during soil erosion events.

2.6.1 Nutrients: Phosphorus and Nitrogen

Phosphorus and nitrogen are two nutrients that are essential for plant growth and crop production. Both nutrients are components of chemical fertilizers, animal manures and decomposing crop residue. In soil, they are found dissolved in soil water, attached to soil particles or as particles of fertilizer.

Nitrogen and phosphorus can be transported by runoff and leaching to surface water and groundwater. Elevated levels of these nutrients degrade water quality by promoting growth of rooted aquatic plants and algae.

Phosphorus is the nutrient that most greatly affects aquatic plant growth. Even a small amount of phosphorus, measured in parts per billion, can promote the growth of algae and other aquatic plants. Large masses of algae, called **algal blooms**, are a key concern for several reasons:

- ▶ When algal blooms exhaust the supply of phosphorus, they die and start to decompose. During decomposition, dissolved oxygen is removed from the water by microorganisms that break down the organic material. The lack of oxygen can result in the death of fish and other aquatic organisms.
- ▶ Some types of blue-green algae can release toxins deadly to livestock and humans when the algal bloom decomposes.
- ▶ Algae can block water intakes, reduce the appeal of water bodies for recreation, and give an unpleasant taste and odour to drinking water.

Nitrate is a form of nitrogen that is highly susceptible to leaching because it is readily dissolved in water. Drinking water guidelines place an upper limit on the allowable concentration of nitrate (10 mg/L of nitrate-nitrogen) in water because high concentrations can pose health hazards to humans and livestock. Ammonia, another form of nitrogen, poses a threat to water quality because it can be toxic to aquatic organisms such as fish.

Factors affecting the transport of nutrients to surface water and groundwater:

- ▶ Areas at greater risk of water erosion (see Section 2.2.1) are also at greater risk for contributing nutrients to runoff and surface waters.
- ▶ Infiltration of water is slower in fine-textured soils (silty and clay soils), making them more likely to have runoff, and increasing the risk of surface water contamination. Infiltration is faster in coarse-textured soils (sandy soils) and more likely to lead to groundwater contamination.
- ▶ Wet soils that are frozen have lower infiltration, which can lead to increased runoff and a greater risk of surface water contamination.
- ▶ Permanent vegetation cover along the banks of a surface water body can capture some of the nutrients in runoff.
- ▶ If there is an excess concentration of a particular nutrient, then there is a greater risk of transport of that nutrient.

2.6.2 Pathogens

A **pathogen** is a disease-causing microorganism. Three classes of microorganisms are important in disease transmission via water: bacteria, viruses and parasites. Pathogens found in contaminated water may include strains of *Escherichia coli*, *Camphylobacter* species, *Salmonella* species, *Shigella* species, *Cryptosporidium parvum* and *Giardia lamblia*.

Livestock manure can harbour a number of these pathogens. Runoff from manured fields can carry the pathogens to surface waters, and leakage from improper manure storage can potentially contaminate surface water and groundwater.

Ingestion of pathogens from manure can lead to various illnesses in humans. Most pathogens in water can be killed through disinfection with chlorine; however, some pathogens, including *Cryptosporidium parvum*, are resistant to chlorine and require more expensive treatment methods.

Factors affecting the transport of pathogens to surface water and groundwater:

- » Areas at greater risk of water erosion (see Section 2.2.1) are at greater risk for contributing pathogens to surface water.
- » Areas with a greater risk of contributing nutrients from manure to surface waters are also at greater risk of contributing pathogens.
- » Downward movement of water is slower in fine-textured soils, making them more likely to have runoff and a greater risk of contributing contaminants to surface waters. Downward movement of water in coarse-textured soils is faster and more likely to lead to leaching and a greater risk for shallow groundwater contamination.
- » Wet soils that are frozen have lower infiltration, which can lead to more runoff and a greater risk for contributing pathogens to surface water.

2.6.3 Pesticides

Pesticides are chemicals designed to control or kill specific plants, insects, animals and disease-causing organisms. Pesticides can be grouped into herbicides, insecticides, fungicides and rodenticides.

Pesticides can be harmful to organisms other than the **target** organism. When the pesticides are transported to water, any organism that resides in the water or ingests the water comes into contact with the pesticide. While some pesticides degrade quickly in the environment, others can accumulate in the tissue of organisms, in a process called **bioconcentration**. With every step in the food chain, larger quantities of the accumulated pesticide are eaten. This accumulation, called **biomagnification**, may continue to the point where the animals are harmed or are unsafe for human consumption (Figure 2.7).

FIGURE 2.7

BIOMAGNIFICATION

Over-reliance on certain pesticides can also lead to the development of resistance in the target species.

Pesticides can be carried from the target area to water bodies in several ways: dissolved in runoff water or infiltrating water, as soil-attached particles carried by wind or runoff water, or as spray drift (see Section 2.7.3).

Factors affecting transport of pesticides to surface water and groundwater:

- + Heavy rainfall soon after a pesticide application greatly increases the risk of contaminating runoff and groundwater, and also reduces the effectiveness of the pesticide application.
- + Pesticides can reach surface water directly through spills or improper mixing/loading techniques. In particular, backflow, the backward flow of liquid from the sprayer through the filling hose when the pump is shut off, can cause serious contamination of the water source used for mixing.
- + Pesticides that are very soluble have a greater potential to percolate through the soil and reach the groundwater.
- + Areas at greater risk for erosion (see Section 2.2) are at greater risk for the movement of soil-attached pesticides.

Table 2.4 provides more details on the factors affecting the transport of pesticides to water bodies.

TABLE 2.4

FACTORS AFFECTING PESTICIDE TRANSPORT TO WATER		
CHEMICAL FACTORS	Solubility	Soluble pesticides will move easily with water and are more likely to leach through soil.
	Binding to soil particles	Some chemicals adhere very tightly to soil particles and are not subject to loss by dissolving into water, but can be carried to water bodies through erosion of soil particles.
	Rate of breakdown (half life)	A persistent chemical, because it is around longer, is more likely to be transported than one that breaks down quickly.
	Rate of application	A chemical with a low application rate is less likely to move away from the target.
	Timing of application	Chemicals applied in the fall or early spring have a greater chance of loss.
SOIL FACTORS	Texture	Sandy soils, which allow greater water movement and bind less tightly to chemicals, are subject to more losses.
	Slope	Steep slopes that are erosion prone are more likely to lose pesticides that are attached to soil particles.
	Depth to water table	Shallow water tables are more easily contaminated. In the spring and fall when water tables are high, chemicals are more likely to move downward and contaminate the groundwater.
APPLICATION FACTORS	Weather following spraying	Heavy rain within a few days of spraying can move significant proportions of the applied chemicals.
	Operator care	Excessive rates, uncalibrated sprayers, careless handling, spraying too close to streams or lakes, or spraying when it is too windy can all increase losses.

Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food: 1992, *Best Management Practices: Field Crop Production*, Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, p. 36.

Factors affecting transport of pesticides to surface water and groundwater:

Heavy rainfall soon after a pesticide application greatly increases the risk of contaminating runoff and groundwater, and also reduces the effectiveness of the pesticide application.

Pesticides can reach surface water directly through spills or improper mixing/loading techniques. In particular, backflow, the backward flow of liquid from the sprayer through the filling hose when the pump is shut off, can cause serious contamination of the water source used for mixing.

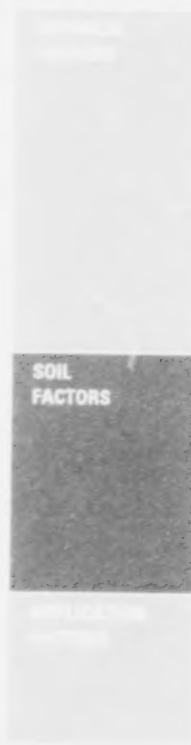
Pesticides that are very soluble have a greater potential to percolate through the soil and reach the groundwater.

Areas at greater risk for erosion (see Section 2.2) are at greater risk for the movement of soil-attached pesticides.

Table 2.4 provides more details on the factors affecting the transport of pesticides to water bodies.

TABLE 2.4

FACTORS AFFECTING PESTICIDE TRANSPORT TO WATER

 SOIL FACTORS	Solubility	Soluble pesticides will move easily with water and are more likely to leach through soil.
	Binding to soil particles	Some chemicals adhere very tightly to soil particles and are not subject to loss by dissolving into water, but can be carried to water bodies through erosion of soil particles.
	Rate of breakdown (half life)	A persistent chemical, because it is around longer, is more likely to be transported than one that breaks down quickly.
	Rate of application	A chemical with a low application rate is less likely to move away from the target.
	Timing of application	Chemicals applied in the fall or early spring have a greater chance of loss.
	Texture	Sandy soils, which allow greater water movement and bind less tightly to chemicals, are subject to more losses.
	Slope	Steep slopes that are erosion prone are more likely to lose pesticides that are attached to soil particles.
	Depth to water table	Shallow water tables are more easily contaminated. In the spring and fall when water tables are high, chemicals are more likely to move downward and contaminate the groundwater.
	Weather following spraying	Heavy rain within a few days of spraying can move significant proportions of the applied chemicals.
	Operator care	Excessive rates, uncalibrated sprayers, careless handling, spraying too close to streams or lakes, or spraying when it is too windy can all increase losses.

Reprinted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1996. *Water Contamination by Pesticides: Field Crop Production Operations*. and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1996.

2.6.4 Sediments

Sediments are soil particles carried by runoff and deposited in water bodies. Sediments can eventually fill in the water body where they are deposited. They can also degrade aquatic habitat and reduce water quality.

Sediment deposition can smother fish eggs, aquatic larvae and other aquatic organisms. Increased sediment in water reduces light penetration, which may inhibit the growth of bottom-rooted aquatic plants, resulting in a shift toward the growth of algae.

Sediments suspended in water decrease the effectiveness of chemical water treatment methods, resulting in the need for expensive pre-treatment of drinking water. Other contaminants, such as nutrients, pesticides, pathogens, or fuel compounds, can be attached to sediment particles, further reducing water quality.

Factors affecting transport of sediments to surface water:

- ✦ Areas at greater risk of soil erosion (see Section 2.2) are also at greater risk for movement of sediments into surface waters.
- ✦ Vegetation along the banks of a water body stabilizes the bank, reducing the risk of erosion by the stream. Bank vegetation also traps sediments carried by runoff, preventing them from entering the water body.



➡ Damaged stream banks contribute sediments to the stream, damaging the aquatic habitat.

Courtesy of Cows and Fish Program

2.6.5 Other Contaminants

Fuels, lubricants, solvents, and paints can be a source of pollution. The most common way for these contaminants to enter surface water or groundwater is through spills or leakage.

Most paint, fuels, lubricants and solvents are toxic to aquatic organisms, and many of these compounds are also toxic to other organisms, including humans, when ingested. Products such as gasoline, diesel fuel and kerosene can move quickly through the soil and into groundwater. It takes only a few litres of gasoline to severely pollute a farmstead's drinking water.

Factors affecting transport of other contaminants to surface water and groundwater:

- ▶ Contaminants such as fuels, solvents and paints are easily transported by runoff to surface water bodies and by seepage to groundwater.
- ▶ Areas at greater risk of water erosion (see Section 2.2.1) are also at greater risk for the movement these contaminants in runoff.
- ▶ Infiltration of water is slower in fine-textured soils, making them more likely to have runoff leading to a greater risk of surface water contamination. Infiltration in coarse-textured soils is faster and more likely to lead to groundwater contamination.
- ▶ Wet soils that are frozen have limited infiltration, which can lead to more runoff and a greater risk of transportation to surface water bodies.

For more information on water quality, see *The Health of Our Water* (AAFC), *Primer on Water Quality* (AAFRD).

2.7 Air Quality

Greenhouse gases, blowing soil, pesticide drift, smoke and odour from cropping operations can reduce air quality.

2.7.1 Greenhouse Gases

Water vapour, carbon dioxide, methane, ozone, halocarbons (used in refrigerants), and nitrous oxide are the main **greenhouse gases** in the atmosphere. The trapping of heat by these gases controls the earth's surface temperature. Emissions from human activities are important additional sources of greenhouse gases. Increasing concentrations of these gases are believed to increase global warming. Global warming could result in such problems as more severe or extreme weather events like tornadoes, droughts and winter storms, more forest fires, and damage to water resources.

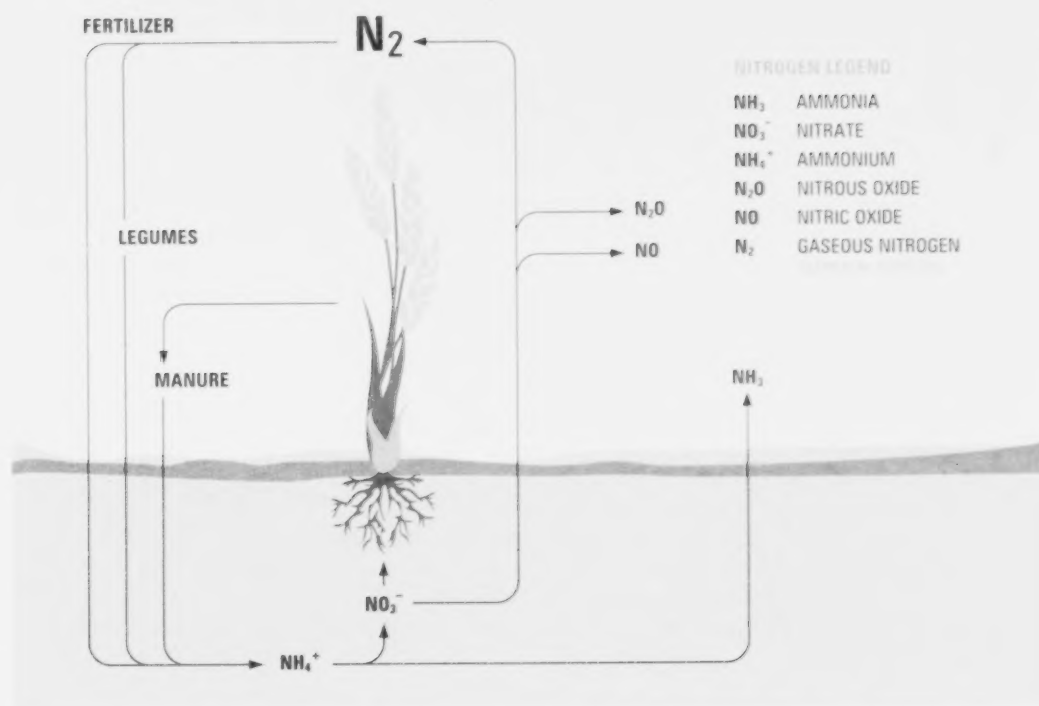
The main greenhouse gases emitted by the cropping industry are nitrous oxide and carbon dioxide. Nitrous oxide is emitted from soil through a biological process under low oxygen conditions (called anaerobic conditions). Thus waterlogging and any high nitrogen inputs (such as nitrogen fertilizer, legume crop residues, or manure) will increase nitrous oxide production.

Factors affecting emissions of nitrous oxide:

Emission of nitrous oxide is part of the cycling of nitrogen through the soil and air (Figure 2.8). The nitrogen cycle is affected by complex, interacting factors. In general, nitrous oxide emissions tend to increase:

- when the soil is waterlogged.
- when more nitrogen fertilizer or manure is applied to soils that are or become waterlogged.
- when nitrogen fertilizer is broadcast rather than banded.
- when nitrogen is applied long before the time the crop will use it (e.g. emissions from fall banding will be more than emissions from spring banding).
- when manure is left on the soil surface (rather than being incorporated into the soil or injected).

FIGURE 2.8

NITROGEN CYCLE IN AN AGROECOSYSTEM

Adapted from: Figure 21 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R. and Grace, B. (eds). 1999. *The Health of Our Air: Toward Sustainable Agriculture in Canada*. Agriculture and Agri-Food Canada. Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2003.

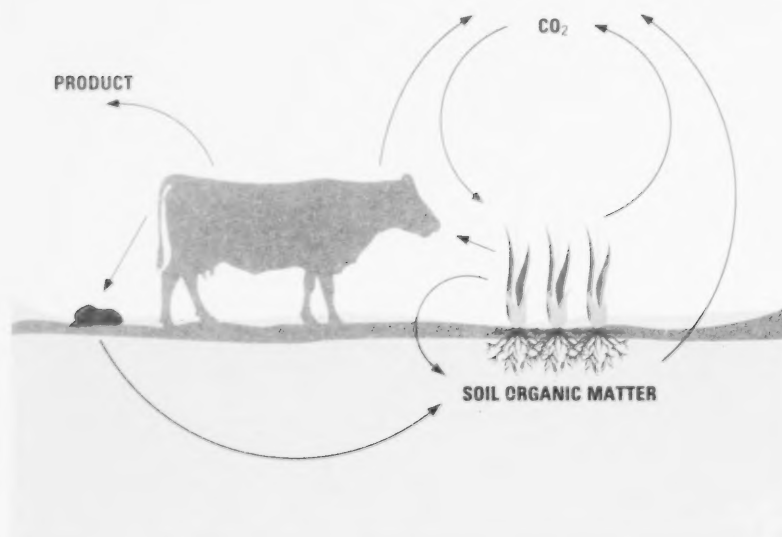
Carbon dioxide emissions from crop production result mainly from decomposition of soil organic matter (Figure 2.9) and burning of fossil fuels. Cropping practices that increase soil organic matter levels remove carbon dioxide from the air and store the carbon in the soil. Carbon storage, also called **carbon sequestration**, reduces agriculture's greenhouse gas emissions.

Factors affecting emissions of carbon dioxide:

- Practices that increase accumulation of soil organic matter (see Section 2.1) reduce carbon dioxide emissions.
- Frequent tillage increases carbon dioxide emissions by increasing the rate of decomposition of soil organic matter and increasing fuel usage.
- Burning of crop residues releases carbon dioxide into the atmosphere.
- Renewable energy sources, such as wind or solar power, do not emit carbon dioxide.

FIGURE 2.9

CARBON CYCLE IN AN AGROECOSYSTEM



Adapted from: Figure 9 in Janzen, H.H., Desjardins, R.L., Asselin, J.M.R., and Grace, B. (eds). 1999. *The Health of Our Air: Toward Sustainable Agriculture in Canada*. Agriculture and Agri-Food Canada, Publication 1981/E. Reproduced with the permission of the Minister of Public Works and Government Services Canada, 2003.

2.7.2 Dust

Along with being a social concern (see Section 8.2.2), dust also creates environmental problems. It can cause respiratory problems for people and animals. It can reduce visibility on nearby roadways and may result in traffic accidents. Dust may contain diseases, seeds, pollen and plant tissue, as well as agrochemicals, such as pesticides. These materials can cause health problems and, in the case of pesticides, contaminate non-target areas. Dust from road travel can be a concern during such activities as harvesting or manure hauling.



➡ Wind erosion can reduce visibility.

Courtesy of DUC

Factors affecting dust levels:

- ▶ Areas at greater risk of wind erosion (see Section 2.2.2) are at greater risk of contributing dust to the atmosphere.
- ▶ Dust from traffic on gravel roads increases with higher vehicle speeds, more vehicles, and lower moisture conditions.

2.7.3 Pesticide Drift

During pesticide application, spray droplets, mists or vapours may form. These airborne particles can drift and contaminate nearby land and water, and present a hazard to humans, animals and plants.

Spray drift onto water bodies can harm water quality and aquatic habitat. Drift toward farmsteads and other residences can cause human health problems or can damage gardens and trees. Some pesticides accumulate through **bioconcentration** and **biomagnification**, harming fish, birds and mammals higher in the food chain (Figure 2.7). Herbicide drift onto neighbouring fields can injure or kill sensitive crops in those fields. Insecticide drift can increase the risk of harming or killing non-target, beneficial insects.



⇒ Herbicide drift can injure or kill crops on neighbouring fields.

Courtesy of Agriculture and Agri-Food Canada - Tom Wolf

Factors affecting pesticide drift:

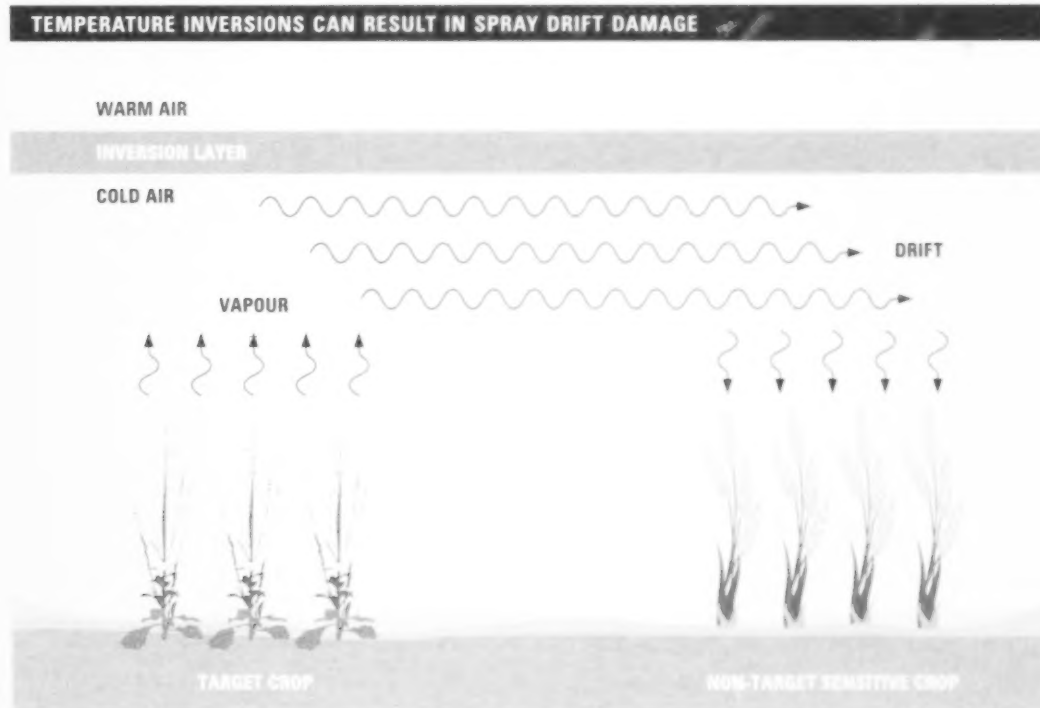
- ▶ Small spray droplets drift more easily than larger droplets.
- ▶ Wind speeds greater than 16 km/h create a high risk of spray drift.
- ▶ Air temperatures above 25°C and low relative humidity reduce droplet size through increased evaporation, and so increase the risk of spray drift.
- ▶ Higher boom heights increase the risk of spray drift. Boom height determines how much time droplets are exposed to air currents and other forces that reduce droplet size.
- ▶ Volatile pesticides can easily move into the air and be deposited elsewhere. Volatility is the ability of a substance to vaporize into the air. Higher spray pressure tends to increase spray drift.
- ▶ Spraying during a temperature inversion can increase the risk of spray drift (Figure 2.10).

Temperature Inversions and Pesticide Spraying

Air temperature generally becomes cooler higher in the sky. However, during a temperature inversion, the air gets warmer with increased elevation. Temperature inversions occur during very calm conditions, usually in early morning or late evening. An inversion is occurring when it seems you can hear noises for miles or when smoke moves across the sky in a cloud rather than moving upwards and dispersing.

During an inversion, spray droplets can hang in the air as a concentrated cloud for some time after application. When winds pick up, the cloud can move to adjacent areas.

FIGURE 2.10



Adapted from: Figure 14 in Ozkan, H. Erdal. 2000. Reducing Spray Drift. Bulletin 816-00. The Ohio State University Extension Bulletin.

2.7.4 Smoke

Smoke contains soot (particles of carbon) that can cause respiratory problems. Smoke can also reduce visibility. If the fire gets out of control, it can endanger property and life, and there may be liability associated with fire and smoke hazards. Before burning, check local bylaws; many municipalities require permits for burning.

The two most common reasons for burning in a crop production system are to get rid of crop residues and to get rid of brush piles from cleared land. Burning of crop residues leaves the soil prone to erosion and all the problems that soil erosion generates (see Section 2.2). As well, excess straw beyond that needed to protect the soil has many potential uses, including bedding and roughage for livestock.



⇒ Burning crop residues leaves soils prone to erosion.

Courtesy of Roger Bryan

Factors affecting smoke from burning:

- ✦ Higher wind speeds and drier conditions increase the risk of fires getting out of control.
- ✦ The material being burnt affects the amount of smoke and odour; green material is smokier.
- ✦ The degree of smoke hazard increases when smoke blows across roads or toward residences.
- ✦ Burning in the middle of the day reduces the degree of smoke hazard because air movement is usually better, resulting in better smoke dispersal.

2.7.5 Odour

Odours are primarily from ammonia and hydrogen sulphide. The main sources of ammonia and hydrogen sulphide in crop production are manure, fertilizers, crop residues and silage.

Factors affecting release of ammonia or hydrogen sulphide to the air:

- ▶ Ammonia is part of the cycling of nitrogen in the soil and air, which is affected by many factors. In general, ammonia emissions increase under wetter conditions, warmer conditions and when the soil is more alkaline.
- ▶ The release of ammonia tends to increase as more nitrogen fertilizer is applied and if the fertilizer is broadcast rather than incorporated or banded. The amount of ammonia released also depends on the type of fertilizer. Coated urea fertilizer releases nitrogen slowly, reducing the risk of nitrogen losses to the air.
- ▶ Incorporating surface-applied manure soon after application or injecting manure reduces ammonia and hydrogen sulphide emissions.

For more information, see *The Health of Our Air* (AAFC), *Greenhouse Gas Emissions and Alberta's Cropping Industry* (AAFRD), *A Workbook on Greenhouse Gas Mitigation for Agricultural Producers* (AAFRD) and *Pesticide Drift Management* (Alberta Environmental Protection).

2.8 Wildlife Habitat

Agriculture relies on a diversity of biological and natural resources to sustain key functions of agro-ecosystems in support of food production and security. Conserving and restoring wildlife habitat contributes to biodiversity and to the ecological functions on which agriculture depends such as:

- ▶ protection of water quality
- ▶ regional water cycling
- ▶ nutrient cycling
- ▶ maintenance of soil fertility
- ▶ pollination
- ▶ pest control
- ▶ climate regulation

Agricultural ecosystems (or **agro-ecosystems**) are ecosystems used for agriculture. Each species in an agro-ecosystem is part of a web of ecological relationships connected by flows of energy and materials. Farmers and ranchers manage this flow. Along with their environmental benefits, healthy, diverse habitats provide recreational, economic and quality of life benefits for farmers and rural communities.



⇒ Fall rye cover provides nesting habitat.

Courtesy of DUC

Factors affecting habitat on crop land:

- * Agricultural practices that protect soil, water and air quality also help maintain habitat. These include such practices as reducing tillage, maintaining perennial cover, planting winter cereals, maintaining buffer zones along streams and lakes, planting shelterbelts and preventing spray drift.
- * Draining or infilling wetlands, whether they are permanent or temporary, reduces habitat.
- * If not properly managed, pesticide applications can harm non-target plants and animals.
- * Some land uses can fragment natural landscapes, reducing habitat quality by reducing the ability of wildlife to move from one area to another.

2.9 Information Sources

2.9.1 Contacts

- * Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- * Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada; website: www.agr.gc.ca/pfra
- * Reduced Tillage LINKAGES: phone: 1-780-422-7922; website: <http://reducedtillage.ca>
- * Cows and Fish Program (the Alberta Riparian Habitat Management Program): phone: 1-403-381-5538; website: <http://www.cowsandfish.org/index.html>
- * Ducks Unlimited Canada: phone: 1-780-489-2002; website: <http://www.ducks.ca/index.html>

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CHAPTER 3.0

Cropping Practices

This chapter provides information on a wide range of beneficial management practices suited to cropping practices and production in Alberta.

3.1 General Considerations

Soil testing and record keeping are fundamental to managing your operation in an agronomically, economically and environmentally sound way. Alberta's *Agricultural Operation Practices Act* sets the minimum standards for soil testing and record keeping for producers who apply more than 500 tonnes of manure (wet weight) annually. However, all producers can benefit from regular soil testing and good record keeping.

3.1.1 Soil Sampling and Testing

Soil testing provides an inventory of plant-available nutrients and other soil chemical factors important for crop production. This information gives a basis for recommending applications of additional nutrients. Tailoring fertilizer applications to the crop's needs is the key to avoiding overapplication and reducing impacts on water, soil and air quality. It also helps save money and conserve energy.

Sampling

The key to any soil testing program is taking samples which accurately represent the field's nutrient levels. A fertilizer recommendation based on a sample that is not representative will not be correct.

For representative samples, you need to take into account the variability in soil nutrient levels that often occurs within fields, even on fields that seem uniform (see following section on "Soil Sampling Strategies"). Nutrient levels can be influenced by many factors such as topography and soil type. For example, nutrient levels can change along a slope, especially if erosion carries nutrient-rich topsoil from the hilltop to the low area. Saline spots, poorly drained depressions, and eroded knolls should not be sampled unless they represent a significant portion of the field. If they do represent a significant part of the field, they should be sampled separately.

Collect samples from 20 to 30 locations per field. At each location, take samples at depth intervals of: 0 to 15 cm (0 to 6 in), 15 to 30 cm (6 to 12 in), and 30 to 60 cm (12 to 24 in). Including the three depths allows monitoring of leachable nutrients. Record the sampling locations and the soil conditions at sampling (temperature, moisture, crop cover).

Mix the samples from the same depth intervals, creating one large sample for each of the three depth intervals. Remove about 0.5 kg (1 lb) from each large sample. Submit each of the 0.5 kg sub-samples to a commercial lab for analysis.

Soil Sampling Strategies

Whole Field Composite Sampling

Take 20 to 30 cores from representative locations throughout the field (Figure 3.1). Mix the cores together, and submit about a 0.5 kg (1 lb) sub-sample for each of the three depth intervals.

FIGURE 3.1

WHOLE FIELD COMPOSITE SAMPLING



Landscape-Directed Sampling

Divide the field into several areas based on such factors as soil characteristics, management history, yield potential or slope position. Take a set of samples from each of the areas (Figure 3.2). Additional resources are used to develop the sampling design such as: land use history, yield maps and yield history, air photographs, and soil survey information.

FIGURE 3.2

LANDSCAPE-DIRECTED SOIL SAMPLING



Benchmark Sampling

Divide the field into several areas based on such factors as soil characteristics, management history or yield potential. Take 15 to 20 samples from each area in a location that is representative of that area of the field (Figure 3.3). Sample at the same locations each year. For each area of the field, mix the samples from the same depth interval.

FIGURE 3.3

BENCHMARK SOIL SAMPLING



Grid Sampling

Sample soils at regular intervals throughout the field (e.g. every 100 m) (Figure 3.4). Do not mix the cores together. For most producers, the large number of samples required in this approach is not justified in terms of the economic returns.

FIGURE 3.4

GRID SOIL SAMPLING



Figures 3.1, 3.2, 3.3 and 3.4 adapted from: McNeil et al. 2002. Nutrient Management Planning for Livestock Production: Class Participant Package. Alberta Agriculture, Food and Rural Development, Alberta Cattle Commission, Alberta Environmentally Sustainable Agriculture Program, and Canada-Alberta Farm Business Management Program.

Testing

Soil test reports provide soil nutrient results and recommend fertilizer rates. The lab will test for the nutrients you specify. You can also ask for tests to assess specific soil concerns, such as levels of salt or heavy metals.

The lab's fertilizer recommendations are based on the soil nutrient levels as well as such factors as the location of the field, previous crop, intended crop, expected yield, and soil moisture content. For more information on nutrient application rates, see Section 3.6.

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD), *Crop Nutrition and Fertilizer Requirements* (AAFRD) and *Alberta Fertilizer Guide* (AAFRD), or contact your local fertilizer dealer.

3.1.2 Sampling and Testing Manure

The nutrient content of manure can vary greatly depending on the type of animal and how the animal is managed as well as on manure handling and storage practices. Manure sampling and testing is used to determine the manure's actual nutrient content, determine the appropriate application rate, and identify what other nutrients may be required by the crop.

Sampling

The best time for sampling is during loading or land application. Submit the sample for analysis as soon as possible after sampling. Generally, a sample of about 5 lb (2.25 kg) from the possibly hundreds of tons of manure is sent for analysis. (See box for sampling procedures.)



➡ Manure sampling and testing is used to determine the manure's actual nutrient content.

Courtesy of PAMI

Sampling Liquid Manure

1. Take samples each time the storage is emptied because the nutrient status varies with the time of year.
2. Agitate the storage completely before sampling.
3. Collect the sample from various depths as the storage is being emptied because the nutrient status varies with depth. Thoroughly mix 10 to 20 samples from each depth and transfer a portion to a plastic jar. The jar should be only half full to avoid gas buildup and potential explosion.
4. Seal the container tightly, and store it in a cool place.
5. Label the sample, including name, date and storage identification.
6. Submit the sample to the lab within 24 hours.

Sampling Solid Manure

1. Sample manure each time the storage is emptied until a trend is evident in the results. Then sample every few years or when a change in management occurs (e.g. bedding, storage).
2. Remove the crust to sample the pile.
3. Take a sample (using a pitchfork, for example) from various parts of the pile. Try to take into account visible variations in bedding and moisture content.
4. Place the samples on a clean cement pad or plywood. Chop the samples with a shovel or fork, and mix the samples as thoroughly as possible. Divide the manure into four portions and discard three.
5. Continue dividing and mixing the manure until you can fill a half-litre shipping container.
6. Store the sample in a tightly sealed container in a cool place.
7. Label samples, including name, date and storage identification.
8. Submit the sample to the lab within 24 hours

Adapted from: McNeil et al. 2002. Nutrient Management Planning for Livestock Production: Class Participant Package. Alberta Agriculture, Food and Rural Development, Alberta Cattle Commission, Alberta Environmentally Sustainable Agriculture Program, and Canada-Alberta Farm Business Management Program.

Testing

Alberta labs that test manure are listed on the ManureNet website (http://res2.agr.gc.ca/initiatives/manurenet/manurenet_en.html). Samples should be tested for moisture content (solid manure), total nitrogen, ammonium nitrogen, and total phosphorus. If the soil has other nutrient deficiencies, you can test the manure to see how much of those nutrients it can supply. You can also request additional analyses such as: electrical conductivity (to determine salt content), sodium adsorption ratio, carbon:nitrogen ratio, pH and sodium.

Manure nutrient results should be on a wet (or "as is") basis because manure is spread wet. Manure test results should be in the same units as used when calibrating the manure application equipment (pounds or kilograms). Take special care when converting units. For information on determining manure application rates, see Section 3.6. You can also contact a qualified professional agrologist for more information and advice.

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD).

3.1.3 Record Keeping

Maintaining detailed records for your farm helps you assess your current techniques and refine them for better agronomic, economic and environmental performance.



➡ Use your records to make management decisions.

Courtesy of AAFRD.

Keep records by field and by year. Include all the practices used, the types, rates and dates of application of all inputs used, maps of soil sampling locations, results from soil and manure tests, the crop type and yield, details of any crop disease, weed and/or insect problems, and weather conditions. Keep your records up to date, and retain them for at least five years. Use your records to make management decisions.

See AAFRD's website for lists of software available for field record keeping (<http://www.agric.gov.ab.ca/agdex/agsoft/soft205.html>).

3.1.4 Farm Management Planning

Farm management planning helps farm families to consider and discuss their long-term goals for the family and the farming operation, and to determine the steps needed to reach those goals. It also enables farm families to put environmental considerations in the context of the whole operation.

Along with an overall management plan for the farm, many producers choose to develop plans focusing on specific elements of their operation. For example, an environmental farm plan helps producers to assess their environmental risks and develop a plan to address those risks, and a nutrient management plan helps producers determine the best way to manage nutrients.

3.2 Tillage and Seeding Practices

3.2.1 Conservation Tillage Systems

Conventional tillage systems use multiple tillage passes for weed control, fertilizer application, seed bed preparation and seeding. Conservation tillage systems reduce the amount and intensity of tillage.

Conventional tillage systems can create a number of environmental problems such as:

- ▶ increasing the rate of organic matter decomposition,
- ▶ drying out the soil,
- ▶ reducing the size and stability of soil aggregates, which increases the risk of compaction and crusting, and
- ▶ burying crop residues, which leaves the soil prone to erosion.

Conservation tillage systems include zero tillage, direct seeding and reduced tillage.

Direct Seeding and Zero Tillage

Direct seeding and zero tillage are cropping systems that aim to enhance soil quality and conserve soil moisture.

In a zero tillage cropping system, planting is the only operation that disturbs the soil. In general, not more than 40% of the soil surface is disturbed for seed and fertilizer placement. Many zero till farmers strive for less than 25% disturbance, and some zero tillage systems achieve as low as 10%. The amount of soil disturbance during planting varies with the type of opener.

In direct seeding systems, the soil is not tilled before planting. However, in contrast to zero tillage, direct seeding allows some soil disturbance to deal with special situations. These special instances may include some tillage in the seeding operation to solve immediate weed problems, harrowing to deal with soil crusting or excessive crop residues, or a fall fertilizer injection. Any fall soil disturbance must leave the soil surface level, minimize stubble knock-down and keep most of the crop residue on the surface, in order to conserve soil moisture and increase snow trapping.



➡ Direct seeding conserves soil moisture and improves soil quality.

Courtesy of RTL

The advantages to reducing soil disturbance include:

- ▶ soil moisture is conserved;
- ▶ fuel requirements and equipment wear-and-tear are reduced because fewer passes are needed to complete field operations;
- ▶ standing stubble is maintained, trapping snow for increased spring soil moisture and reducing erosion;
- ▶ weed seeds are less likely to grow on the undisturbed soil surface, and are more likely to be eaten by rodents, birds and insects; and
- ▶ soil erosion is reduced.

Direct seeding and zero tillage offer several other benefits over conventional tillage, such as improved moisture-holding capacity, improved yield potential, better fertilizer use efficiency, and less time spent on field operations. However, changing to these systems requires changes in management of crop residues, weeds and soil fertility. It may also require crop rotation changes to prevent specific pest problems that were previously kept in check by tillage. Some of these considerations are discussed in Sections 3.4 and 3.5.

Reduced Tillage

Reduced tillage systems leave a crop residue cover to prevent erosion and conserve soil moisture. These systems also save time and energy, and costs are usually similar to or lower than those for conventional tillage systems.

Tillage is reduced by replacing some tillage operations for weed control with herbicide applications or by using tillage equipment that helps maintain a good residue cover (e.g. rowweeder).

Minimizing the Impacts of Tillage

If you choose to till:

- * avoid fall tillage so the crop residue cover is retained to trap snow and prevent soil erosion during the fall, winter and spring.
- * replace deep tillage with shallow tillage to minimize disturbance of soil.
- * reduce the number of tillage passes.
- * reduce tillage speed.
- * use implements that bury less residue (see Table 3.1).
- * where possible, use contour tillage. Till and plant crops across the slope, rather than up and down the slope, to prevent runoff from eroding channels down the slope.
- * avoid tillage when the soil is wet.

TABLE 3.1

EFFECT OF TILLAGE EQUIPMENT ON CROP RESIDUE	
IMPLEMENT	PER CENT OF RESIDUE COVER REMAINING AFTER ONE PASS
Moldboard Plow	10
Chisel Plow (less than 12-inch)	50 to 70
Sweeps (20-inch to 30-inch)	80
Blade (more than 30-inch)	90
Offset Disc	50
Tandem Disc	60
Harrow – springtooth	65
Harrow – steel Tooth (more than 12-inch)	95

Source: Timmermans, J. and Larnoy, F. 1998. *An Introduction to Wind Erosion Control*. Alberta Agriculture, Food and Rural Development, Agdex 572-2.

Conservation Fallow Systems

Summerfallowing can be defined as leaving a field without crop growth for a growing season. However, the term is often used to describe one particular type of summerfallow, called conventional fallow, in which the fallow field is tilled frequently. Fields may be left fallow during the growing season to control difficult weed problems, conserve soil moisture, increase short-term nutrient availability, and/or reduce the risk of residue-borne plant diseases.

Conservation fallow systems maintain plant residues on the soil surface to reduce soil erosion, while still providing weed control and soil moisture conservation during the fallow period. These systems include reduced tillage fallow where a combination of tillage and herbicides is used, and chemfallow where herbicides alone are used to control weeds.



⇒ Chemfallow provides protection against soil erosion.

Courtesy of AAFRD.

In comparison to continuous cropping, both conventional and conservation fallow systems decrease organic matter levels over time because fewer plant residues are returned to the soil during fallow years. Fallow systems also increase the risk of nutrients being lost from the soil – emitted to the air or leached away – rather than being used by growing plants. In addition, they increase the risk of formation of saline seeps because soil moisture not used by plants may percolate down to the groundwater, carrying salts that can form a saline seep where the groundwater discharges.

Conventional fallow has additional negative impacts. The lack of crop residue cover leaves the soil vulnerable to erosion, and increases the risk of impacts on water quality, air quality and wildlife habitat from erosion. Tillage raises the soil temperature and increases soil aeration, leading to faster decomposition of soil organic matter. Excessive tillage can also result in crusting and poor soil moisture infiltration.

Therefore, if fields must be summerfallowed, use a conservation fallow system. If summerfallow is used to conserve soil moisture, a direct seeding or zero tillage system may allow summerfallow to be used less often because these tillage systems conserve soil moisture.

For more information, see Alberta Agriculture's Direct Seeding factsheet series available on its website (<http://www.agric.gov.ab.ca>), *No-Till: Making it Work* (AAFC), *Summerfallow and Soil Conservation* (AAFRD), or go to the Reduced Tillage LINKAGES' website (<http://reducedtillage.ca/>).

3.2.2 Seed Quality and Seeding Practices

Seed quality and seeding practices can help to reduce pest problems in crops. A healthy, vigorous crop stand is better able to withstand diseases and insect pests, and the crop emerges faster and covers the ground more completely, allowing it to compete more successfully against weeds.

Seeding practices for healthy stands include:

- ▶ Use new, plump, vigorous, high germination seed. Use certified seed if possible. Avoid cracked, split or damaged seed.
- ▶ Choose crop varieties that are resistant to common diseases in your area.
- ▶ Choose crop types that can outcompete problem weeds.
- ▶ Use a seed treatment to control seed-borne diseases in susceptible crops.
- ▶ Test seeds for disease.
- ▶ Use balanced fertilizer applications (see Section 3.6).
- ▶ Band fertilizer close to the seed so the young crop will have the advantage over weed seeds. However, avoid placing the fertilizer so near to the seed that it damages the plants.
- ▶ In direct seeding systems, seed shallowly where the soil is warmer.
- ▶ As much as possible seed at the optimum seeding time for the crop. Seeding too early or too late may reduce crop yields and quality.
- ▶ Ensure good seed-to-soil contact. In direct seeding, choose a ground opener that provides this in your soil and moisture conditions. Pack the soil after seeding to seal in moisture.
- ▶ Plant at the proper depth for the seed type.

CERTIFIED SEED		SEMENCE CERTIFIÉE	
Kind / Espèce			
OATS			
Variety / Variété			
AC MORGAN			
Grade / Catégorie			
CANADA CERTIFIED / CERTIFIÉ			
Crop Cert. No. / N° du cert. de récolte		Lot No. / N° du lot	
81-8000130-406		395-9-057160	
MEMBER OF THE ASSOCIATION OF OFFICIAL SEED CERTIFYING AGENCIES		MEMBRE DE L'ASSOCIATION D'AGENCES OFFICIELLES DE CERTIFICATION DE SEMENCES	
CFIA / ACIA001 (9/7/05)			

⇒ Good quality seed helps to produce healthy stands.

Courtesy of AAFRD

For more information, see *Seed Row Spacing and Seeding Rates in Direct Seeding* (AAFRD), *Ground Opener Systems* (AAFRD), Canada Grains Council's *Complete Guide to Wheat Management*, and the Flax Council of Canada's *Growing Flax*.

3.3 Erosion Control

In many cases, practices like reduced tillage or direct seeding are sufficient to control wind and water erosion. However, areas that are especially prone to erosion may require additional actions.

3.3.1 Water Erosion Control Structures

The following measures are used to control severe erosion problems such as **gullying**. For such problems, obtain technical advice to find the best solution for your situation.

Grassed waterways are broad, shallow channels designed to carry surface water without causing soil erosion. The grass cover slows the water flow and provides protection against the cutting action of water. The grass also helps trap sediments and other contaminants in the water.



➡ Grassed waterways are broad, shallow channels.

Courtesy of AAEPD

Lined channels are a means of dropping water to lower elevations along steep parts of a waterway. The steep portions are precisely shaped and carefully lined with heavy-duty erosion control matting, a type of geotextile product. The lining is covered with a layer of soil and seeded to grass. The resulting channel is very resistant to erosion. Lined channels are appropriate for waterways that carry water only occasionally and have slopes up to 10%. Companies that sell geotextile products can provide detailed information on installation of their products.



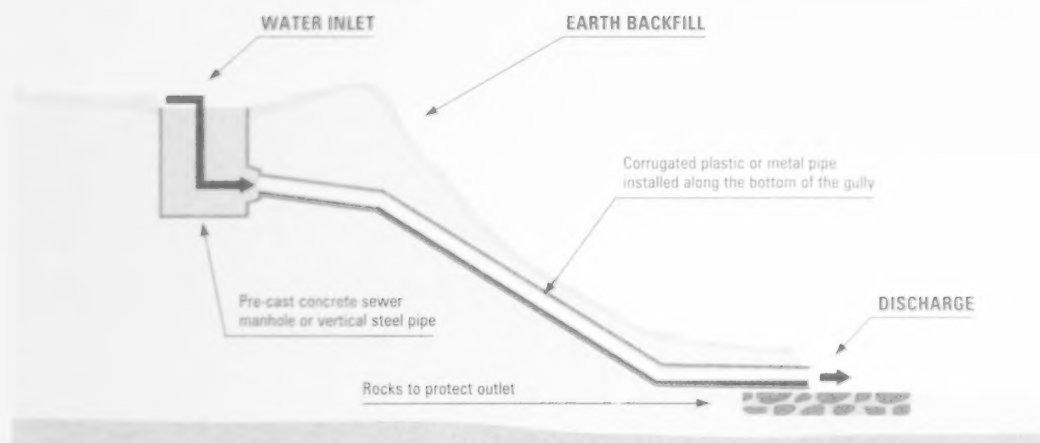
⇒ Construction of a lined channel.

Courtesy of AAEPD

Drop structures are constructed along waterways to drop water to lower elevations without causing erosion (Figure 3.5). They are constructed of concrete, wood, metal or rock. Drop structures are the most costly but occasionally the most appropriate form of erosion control at specific locations along a waterway.

FIGURE 3.5

DROP STRUCTURE



Adapted from: Vanderweil, D. and Abtday, S. 1997. *An Introduction to Water Erosion Control: Agriculture, Food and Rural Development*, Agdex 572-3

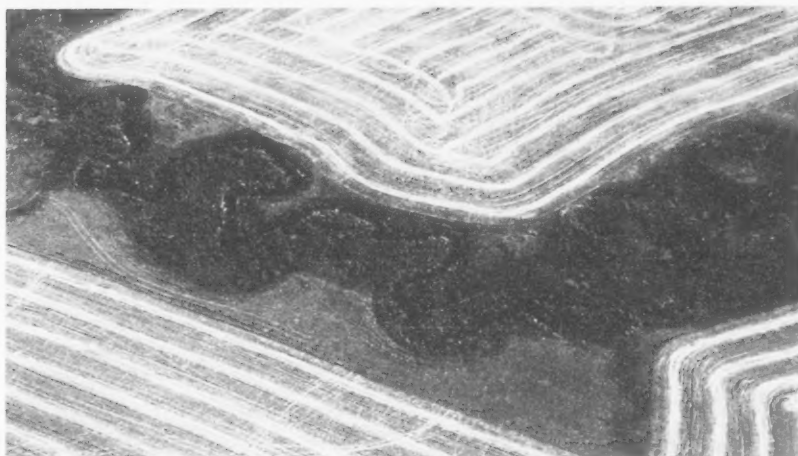
For more information, see *An Introduction to Water Erosion Control*(AAFRD), *Watercourse Improvement and Gully Restoration*(AAFRD) and *Grassed Waterway Construction* (AAFRD).

3.3.2 Buffer Zones and Riparian Areas

A buffer zone is an area of land developed or conserved to reduce erosion, intercept contaminants and provide wildlife habitat along the side of a stream or lake. Riparian areas are lands adjacent to streams and lakes where the vegetation and soils are strongly influenced by the presence of water.

Healthy, well-vegetated buffer zones and riparian areas minimize impacts from runoff on streams and lakes by filtering out some of the soil particles and other contaminants before the runoff enters the water body. They also protect stream banks and lake shorelines from erosion, and they store water, help in recharging groundwater, reduce flood damage, and enhance fish and wildlife habitat.

Healthy buffer zones and riparian areas can remove up to 50% of phosphorus, 90% of sediment and 80% of nitrate runoff from fields before the runoff reaches the water body. In general, the wider the buffer zone, the more buffering it provides.



➡ Buffer zones and riparian areas minimize impacts on streams and lakes.

Courtesy of Cows and Fish Program

To fulfil these functions, the buffer zone and riparian area must be well vegetated with a variety of plant types suited to the local conditions. If these areas are seriously damaged, for example by erosion or flooding, the damage should be repaired.

For more information, see *The Health of Our Water* (AAFC) or Cows and Fish's *Caring for the Green Zone*, or visit the Cows and Fish Program website (<http://www.cowsandfish.org/>).

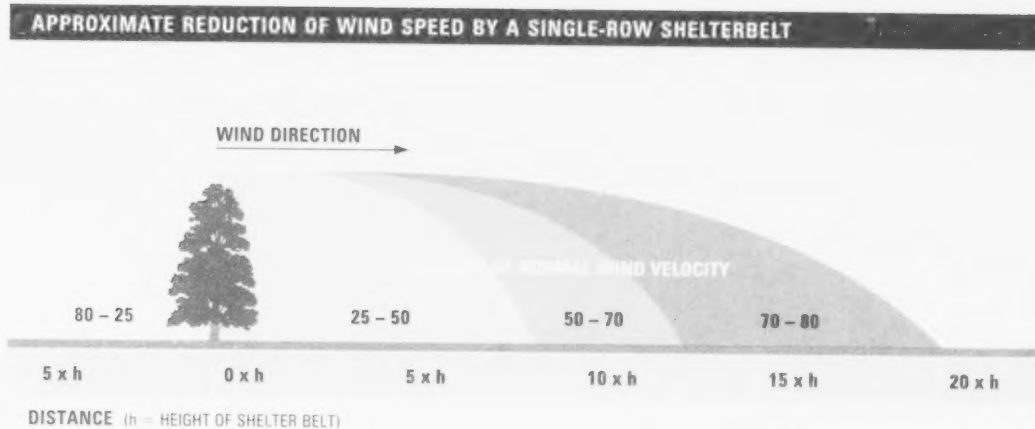
3.3.3 Shelterbelts

A shelterbelt is a barrier of trees or shrubs. Field shelterbelts are used to shelter agricultural fields, while farmstead shelterbelts are planted around farmyards or livestock facilities. Trees and shrubs are also planted in blocks for woodlots or wildlife habitat.

Field shelterbelts decrease wind erosion by reducing wind speeds for distances up to 20 times the height of the trees (Figure 3.6). They also trap snow for increased spring soil moisture, reduce wind damage to crops, decrease evaporation of soil moisture, and store carbon.

Shelterbelts are most effective when planted across the prevailing wind direction. For increased sheltering effects, the shelterbelts can be spaced more closely together; for maximum wind erosion control, plant the rows less than 200 m (660 ft) apart.

FIGURE 3.6



Adapted from: Figure 1 in Timmermans, J. and Casement, B. 1994. *Field Shelterbelts for Soil Conservation*. Alberta Agriculture, Food and Rural Development, Agdex 277/20-3.

To get the maximum benefit from your shelterbelts, you will need to design the belt, select species suited to your site, prepare the site for planting, control weeds for the first few years after planting, and do pruning, watering and other maintenance. New options for shelterbelt weed control – such as plastic, fabric or bark mulches – have reduced the effort required to establish shelterbelts. Manage shelterbelts for longevity; for example, if some of the trees in the shelterbelt die, they should be replaced.



➡ Multispecies shelterbelts reduce the risk of a single disease wiping out an entire shelterbelt system.

Courtesy of Agriculture and Agri-Food Canada – PFRA

For more information on planning, planting and maintaining field shelterbelts and to obtain trees, contact your local AAFC – PFRA office or your Agricultural Service Board. Shelterbelt publications include *Field Shelterbelts for Soil Conservation* (AAFRD), *Shelterbelt Planning for the Farm and Field* (AAFC), and *Weed Control for Alberta Shelterbelts* (AAFRD).

FIGURE 3.6

APPROXIMATE REDUCTION OF WIND SPEED BY A SINGLE-ROW SHELTERBELT



*Adapted from Figure 1 in Timmermans, J. and Desmet, B. 1982. Wind Shelterbelts and Soil Conservation. *Soil Conservation Society of America Proceedings* 46(2): 277-283.*

To get the maximum benefit from your shelterbelts, you will need to design the belt, select species suited to your site, prepare the site for planting, control weeds for the first few years after planting, and do pruning, watering and other maintenance. New options for shelterbelt weed control – such as plastic, fabric or bark mulches – have reduced the effort required to establish shelterbelts. Manage shelterbelts for longevity; for example, if some of the trees in the shelterbelt die, they should be replaced.



— Multispecies shelterbelts reduce the risk of a single disease wiping out an entire shelterbelt system.

Courtesy of Agriculture and Agri-Food Canada (AAFC)

For more information on planning, planting and maintaining field shelterbelts and to obtain trees, contact your local AAFC – PERA office or your Agricultural Service Board. Shelterbelt publications include *Field Shelterbelts for Soil Conservation* (AAFRD), *Shelterbelt Planning for the Farm and Field* (AAFC), and *Weed Control for Alberta Shelterbelts* (AAFRD).

3.3.4 Strip Cropping

Strip cropping is the practice of alternating strips of crops with strips of fallow. The strips run along the contours of the land if the main purpose is to reduce water erosion. They go across the prevailing direction of wind if the main purpose is to reduce wind erosion. Crop residues on the fallow strips are retained with reduced tillage fallow or chemfallow. The strip width is based on the convenient width for equipment operation.



➡ Strip cropping helps to reduce erosion on fallow land.

Courtesy of AAFRD

For more information, see *Strip Farming for Wind Erosion Control* (AAFC – PFRA).

3.3.5 Cover Crops

A cover crop for erosion protection is usually planted later in the growing season (e.g. early August) to provide enough leafy top growth to protect the soil. It may be planted just before a fallow year or after crops such as sugar beets, potatoes and beans that leave little residue cover.

Cover crops are typically spring cereals, which are inexpensive to seed, killed by freezing over the winter, and competitive with weeds in the fall but not competitive with the following crop.

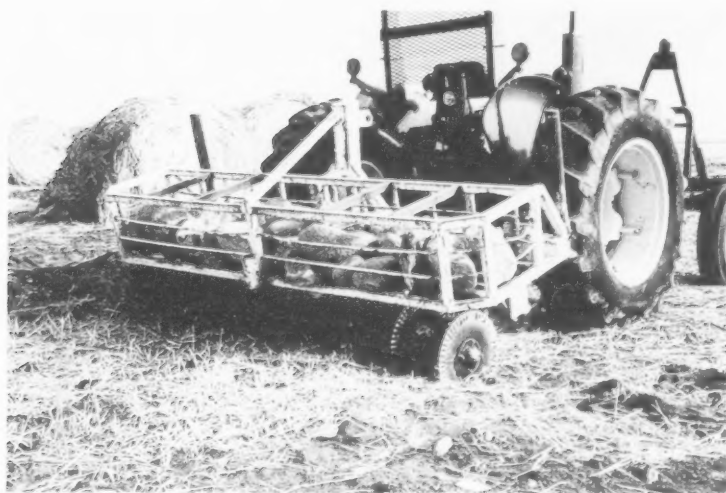
Cover crops use some of the nutrients in the soil but only for a short time, and the used nutrients are cycled back through decomposition, becoming available to the subsequent crop. The amount of soil moisture used by the cover crop is small and comes from shallow depths, and it is usually replaced over the winter.

For more information, see *Summerfallow and Soil Conservation* (AAFRD).

3.3.6 Emergency Wind Erosion Control

Wind erosion may still occur even if preventive measures are taken. Dry soil, poor snow cover, poor residue cover from low-yielding crops, and persistent strong winds make controlling erosion a formidable challenge.

Emergency controls are used when wind erosion is imminent or has started. The two basic types of emergency measures are: increasing the surface roughness of a field; and covering the soil with straw or manure.



→ A straw crimper can be used to anchor straw for emergency erosion control.

Courtesy of AAFRD



→ Rows of square bales can be set at right angles to the wind.

Courtesy of AAFRD

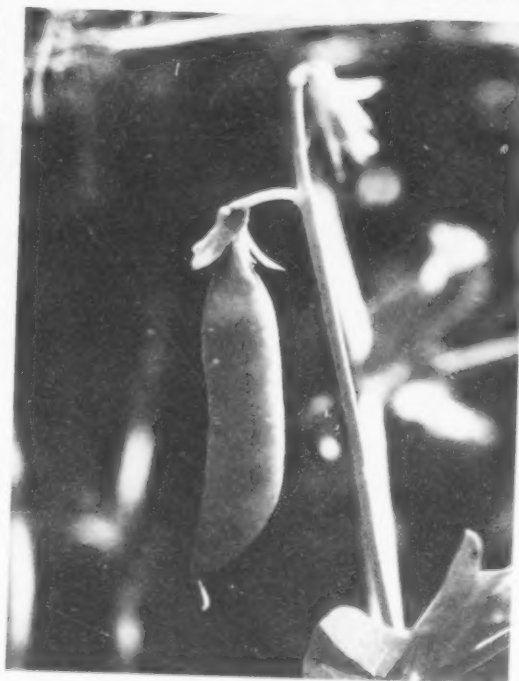
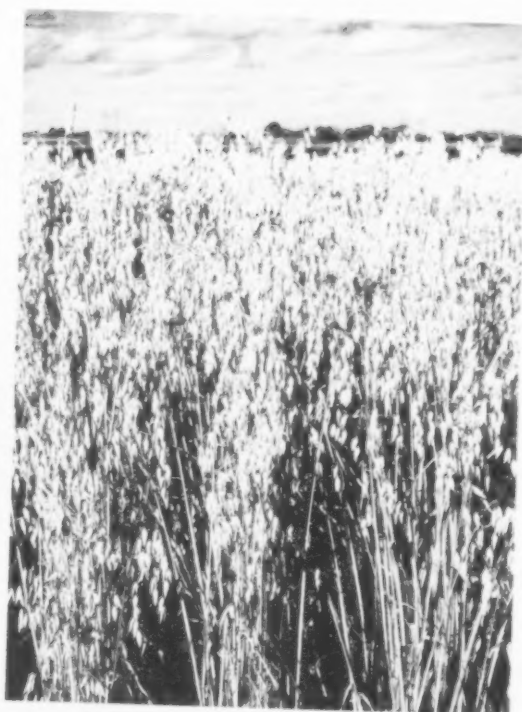
For more information, see *Emergency Measures for Control of Wind Erosion* (AAFRD).

3.4 Cropping Rotations

Although growing a more varied crop rotation requires increased management skills, it can provide many rewards. For example, it helps to reduce diseases, insect pests and weeds in the rotation, in comparison to a cropping system that relies on one or two crops. As well, varied rotations can help to diversify the operation and widen the windows for seeding and harvesting, lowering the production risk.

Rotations can be selected to achieve a variety of objectives, such as to: help manage crop residues, make the most of available moisture, build organic matter, reduce nitrogen fertilizer inputs, vary herbicide types (to avoid creating herbicide-resistant weeds), and lower excessive levels of soil nutrients.

Table 3.2 provides information on the typical amounts of crop residues produced per bushel of grain when planning a rotation to manage residue amounts. For example, after growing a crop that produces very little straw, you may wish to grow a crop that produces more straw.



➡ Cropping rotations can help to diversify the operation and widen the windows for seeding and harvesting.

Courtesy of AAFC

TABLE 3.2

TYPICAL AMOUNTS OF STRAW AND CHAFF PER BUSHEL OF GRAIN			
CROP	SOIL ZONE	POUNDS OF STRAW PER BUSHEL OF GRAIN *	POUNDS OF CHAFF PER BUSHEL OF GRAIN **
HRS Wheat	Brown	50	20 - 25
	Dark Brown	65	
	Black, Gray	80	
CPS Wheat	Brown	40	20 - 25
	Dark Brown	50	
	Black, Gray	60	
Barley	Brown	30	5 - 10
	Dark Brown	35	
	Black, Gray	45	
Oats	Brown	30	5 - 10
	Dark Brown	35	
	Black, Gray	45	
Canola	Brown	40	15 - 20
	Dark Brown	50	
	Black, Gray	60	
Peas	Brown	40	20 - 25
	Dark Brown	50	
	Black, Gray	60	

* Amount of harvestable straw, assuming about 80% recovery in cereals, and 50% in peas and canola, with 2- to 4-inch stubble left.

** Amount of harvestable chaff, assuming little or no weed chaff.

Adapted from: Hartman, M. 1999. *Estimating the Value of Crop Residues*. Alberta Agriculture, Food and Rural Development. Agdex 519/25.

Crop rotations in drier areas can be designed to improve moisture use efficiency. A logical water-based rotation alternates shallow-rooted crops with deep-rooted crops and combines good agronomic and economic performance while making the most efficient use of water over a wide range of moisture conditions. Table 3.3 provides the average moisture use efficiency for four crops.

TABLE 3.3

AVERAGE MOISTURE USE EFFICIENCY (BU/AC/IN) FOR FOUR COMMON CROPS

SOIL ZONE	WHEAT	BARLEY	CANOLA	OATS
Brown	3.75	5.70	2.60	7.10
Dark Brown	4.00	6.20	2.80	7.75
Black	4.25	6.40	3.20	8.20
Gray	4.75	7.20	3.60	9.10

Adapted from: EuroTest Laboratories, Soil Climate Zones of the Canadian Prairies.

3.4.1 Continuous Cropping

In continuous cropping, crops are grown every year with no fallow years in between. As noted in Section 3.2, summerfallow decreases soil organic matter content and soil quality in most situations. Where summerfallowing is used to conserve soil moisture, direct seeding and reduced tillage systems may allow summerfallow to be used less often because these systems conserve soil moisture by reducing evaporation and increasing infiltration.

Rotations benefit all crops in the rotation. For example, wheat or barley grown after peas or canola usually performs better by about 10 to 20% than a cereal grown after a similar cereal crop.

In annual crop rotations, it is best to avoid planting a field with the same crop two or more years in a row. Alternating long-season crops with short-season crops can improve weed control because pre-seeding and in-crop herbicides can be applied earlier or later in the spring. Also, a short-season crop may be harvested early enough to allow the seeding of winter wheat or fall rye, which can take advantage of early spring moisture (see Section 3.4.2).

Rotating cereals with broad-leaved crops, such as oilseeds or pulses, allows weeds to be controlled with herbicides from different herbicide groups, reducing the risk of developing herbicide resistance. This type of rotation can also break the cycles of most diseases, except for those diseases that remain dormant in the soil or persist on crop residues for long periods.

For more information, see *Crop Rotations in Direct Seeding* (AAFRD).

3.4.2 Fall-seeded Crops

Like any crop, fall-seeded crops have their challenges, but they can be a valuable part of a crop rotation, providing a range of agronomic and environmental benefits. Fall-seeded crops grown in Alberta include winter wheat, winter triticale and fall rye.

Fall-seeded crops provide erosion protection during fall and winter, especially if the crop is seeded into stubble. The stubble also traps snow that insulates seedlings against cold temperatures and increases spring soil moisture. As well, a fall-seeded crop seeded into stubble can provide spring nesting cover for waterfowl and other ground nesting bird species.

TABLE 3.2

TYPICAL AMOUNTS OF STRAW AND CHAFF PER BUSHEL OF GRAIN

Crop	Color	Amount of Straw and Chaff per Bushel of Grain (lb)	Amount of Straw and Chaff per Bushel of Grain (%)
HRS Wheat	Brown	50	20 - 25
	Dark Brown	65	
	Black, Gray	80	
CPS Wheat	Brown	40	20 - 25
	Dark Brown	50	
	Black, Gray	60	
Barley	Brown	30	5 - 10
	Dark Brown	35	
	Black, Gray	45	
Oats	Brown	30	5 - 10
	Dark Brown	35	
	Black, Gray	45	
Canola	Brown	40	15 - 20
	Dark Brown	50	
	Black, Gray	60	
Peas	Brown	40	20 - 25
	Dark Brown	50	
	Black, Gray	60	

* Amount of straw and chaff per bushel of grain is based on the following assumptions:

1. 100% moisture content

2. 100% of the straw and chaff is retained in the grain

Source: Adapted from the National Grain and Feed Association (NGFA) and the National Oilseed Processors Association (NOPA).

Crop rotations in drier areas can be designed to improve moisture use efficiency. A logical water-based rotation alternates shallow-rooted crops with deep-rooted crops and combines good agronomic and economic performance while making the most efficient use of water over a wide range of moisture conditions. Table 3.3 provides the average moisture use efficiency for four crops.

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AVERAGE MOISTURE USE EFFICIENCY (BU/AC/IN) FOR FOUR COMMON CROPS

	1	2	3	4
Brown	3.75	5.70	2.50	7.10
Dark Brown	4.00	6.20	2.80	7.75
Black	4.25	6.40	3.20	8.20
Gray	4.75	7.20	3.60	9.10

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Fall-seeded crops also help in reducing pest problems. For example, seeding a fall cereal into stubble from broad-leaved crops, such as canola, mustard and peas, reduces the risk of insect, disease and weed problems developing in the rotation. Fall-seeded crops are also able to outcompete some weeds that emerge in spring, reducing the need for herbicides.

Although these crops can suffer winterkill and be damaged by spring frosts, they are better able to take advantage of early spring moisture than spring-seeded crops. And when spring weather conditions delay seeding, the fall-seeded crop is already in place. Since these crops mature earlier than spring-seeded crops, they may avoid damage from late summer droughts or frosts. In addition, the earlier seeding and harvesting dates for these crops help to spread out the farm workload and to increase marketing options.

For more information, see *Direct Seeded Winter Wheat* (AAFRD), *Winter Wheat in the Parkland Area of Alberta* (AAFRD) and *Fall Rye Production* (AAFRD).

3.4.3 Perennial Forages

Perennial forages in long-term rotations help to build up soil organic matter, prevent wind and water erosion, and to reduce pest problems in subsequent crops. Several years of forages break some disease and insect cycles, and help to control perennial and annual weeds as long as the forage stand is healthy and vigorous. Weed control is improved if the forage crop is harvested as hay or silage since the weed seeds are often not yet viable at the time of cutting.



⇒ Perennial forages protect and improve the soil.

Courtesy of AAFRD

Hay, pasture, and grass seed crops can be grown in rotations for varying lengths of time. The longer the forage cycle, the lower the cost of rotating into and out of forages in a rotation with annual crops. However, when the forages include legumes, particularly alfalfa, the marginal benefit to subsequent crops decreases after the stand is three years old.

Forages can be successfully established by direct seeding. The higher soil moisture content in direct seeded fields allows these small-seeded crops to be seeded near the soil surface for better germination and emergence. A cover crop can be used to protect an establishing forage crop. To improve forage establishment and to decrease competition for nutrients, light or water, it is best to remove the cover crops as greenfeed or silage.

Methods to remove forages and the choice of crop to be seeded after forage cycle depend on the type of forage stand. Terminating forage stands using herbicides and then direct seeding an annual crop is a recommended practice.

For more information, see *Alberta Forage Manual* (AAFRD), *Crop Rotations in Direct Seeding* (AAFRD), and *Removing Forages from the Rotation in a Direct Seeding System* (AAFRD).

3.4.4 Permanent Cover

Permanent cover refers to forage, grass or tree cover. Areas at high risk for such problems as erosion or soil salinity are usually better suited to permanent cover than annual crops because permanent cover protects the soil all year long, year after year. In addition, permanent cover enhances soil organic matter, carbon storage and wildlife habitat.

Lands benefiting most from permanent cover include the following:

- ▶ Areas with steep slopes or very erodible soils can be used for forage production.
- ▶ Wooded areas with poor soils and steep slopes can be managed as woodlots.
- ▶ Non-irrigated corners of pivot-irrigation fields tend to be focal points for wind erosion. Growing forages or grass on these corners reduces erosion.
- ▶ In areas prone to soil salinity, both the recharge areas and the discharge areas benefit from permanent cover.

3.4.5 Green Manuring

Green manuring is the practice of growing a short-term crop to improve soil tilth, add organic matter and nutrients (especially nitrogen) to the soil, and reduce erosion by providing soil cover. After eight to 10 weeks of growth, the green manure crop is worked into the soil, desiccated with herbicides, or hayed. If a green manure is allowed to grow too long, it will deplete the soil moisture reserve for the next year.

While almost any crop may be used as a green manure crop, annual legumes, such as peas and lentils, or biennial legumes, such as sweet, red or alsike clover, are preferred because these crops can fix nitrogen; that is, with the help of *Rhizobium* bacteria, taking nitrogen from the air and convert it into a form that plants can use.

Tilling down the crop returns most of the fixed nitrogen to the soil. However, it is important to leave some of the crop residues on the soil surface to reduce the risk of soil erosion. Desiccating or haying the crop returns about 60% of the plant material and nitrogen to the field, so these options provide almost as much nitrogen benefit as tilling down the crop. Desiccating the crop maintains a crop residue cover to reduce erosion and enhance snow trapping over the winter. Haying the crop also leaves stubble to prevent erosion and trap snow, and it offers the added advantage of economic returns from the hay.



➡ Green manures add organic matter and nutrients to the soil.

Courtesy of AAFRD

A well managed green manure crop boosts the yield of a subsequent cereal crop. Over the long term, the practice of green manuring will improve soil organic matter content and productivity. In addition, a well established cover crop can provide good weed control. Sweet clover and its residues maintain excellent weed control without cultivation or herbicide applications into the year following the green manure crop.

For more information, see *Legume Green Manuring* (AAFRD).

3.5 Crop Residue Management

Crop residues include straw, chaff and roots. Crop type, variety and yield influence the amount of crop residue produced (Table 3.2). Crop residues can benefit a crop production system, but straw and chaff require proper management.

3.5.1 Spreading Crop Residues

Retaining the straw and chaff on the surface of a field offers many benefits. These include increased snow catch and water infiltration, reduced evaporation, increased soil organic matter, improved soil structure and plant nutrient cycling, decreased erosion, and reduction of some weed species.

In direct seeding, crop residues must be spread evenly to avoid or reduce such problems as: equipment plugging; poor seed germination; disease, weed and insect infestations; nitrogen tie-up in the chaff or straw rows; and cold soil.



➡ The most practical way to manage crop residues is with the combine.

Courtesy of RTL

Key techniques to manage residues in direct seeding systems include the following:

- The most practical way to manage chaff and straw residue is with the combine.
- Residue should be spread uniformly over the entire width of the header cut.
- Harrowing can spread straw but not chaff.
- If harrowing, it is better to harrow in the fall before the straw settles.
- Increased residue clearance of direct planting equipment is crucial.

For more information, see *Residue Management for Successful Direct Seeding* (AAFRD), *Equipment Issues in Crop Residue Management* (AAFRD) and *Managing Crop Residues on the Prairies* (AAFC).

3.5.2 Removing Straw and Chaff

The value of straw and chaff differs greatly from area to area. Deciding whether to sell straw for short-term economic returns or to retain straw on a field to sustain long-term soil productivity can be difficult. Consider the following factors in your decision:

- If the risk of wind or water erosion is moderate to severe, do not remove straw.
- Do not remove straw in drought-prone areas.
- Chaff removal is an option in many areas because chaff does not have much erosion control benefit and is a source of weed seeds.
- If the soil is low in organic matter, retain crop residues.
- Crop residues contain economically significant amounts of macronutrients. However, the actual nutrient contents vary greatly. Test samples for an accurate assessment.

For more information, see *Estimating the Value of Crop Residues* (AAFRD).

3.5.3 Handling Difficult Residue Conditions

High crop yields and unusual weather often leave hard-to-handle crop residue conditions such as crops not harvested due to hail, severe frost or other damage, lodged or snow-flattened crops and crops producing heavy residues such as viny pea crops, sunflowers and flax.

Options for managing residues in these difficult conditions include:

- ▶ **Harrowing:** Harrows spread straw, press loose straw into the soil surface, and disperse straw clumps. This reduces plugging in direct seeding planters.
- ▶ **Mowing:** Even very heavy residue or very tall standing stubble is not usually a problem if it is mowed or shredded. However, mowing can be expensive.
- ▶ **Tillage:** If you decide to till, then you must use enough tillage to mix the straw into the soil so that the planter's ground openers will work without plugging. The first tillage pass after harvest leaves a very poor seed bed condition. Tillage should be followed by harrows or packers to reduce soil moisture loss. Waiting until spring to till allows the residues to break down over the winter.
- ▶ **Baling:** Baling is an option for handling excessive residues.



➡ Harrows can spread straw to reduce plugging in direct seeding planters.

Courtesy of AAFRD.

For more information, see *Handling Difficult Crop Residue Conditions* (AAFRD).

3.6 Nutrient Management

Plants require nutrients in certain amounts, depending on the specific crop. The soil can provide some of these nutrients (Figure 3.7), but additional nutrients usually need to be applied. If insufficient nutrients are supplied, crop yields will drop. However, application of excess nutrients poses a threat to the environment. **Matching nutrient levels to crop demand protects the environment and maximizes the benefit of supplying valuable nutrients to crops.**

The total amount of plant nutrients removed from the soil by a crop depends on the yield: the greater the yield, the greater the amount removed. Based on equal seed yields per unit area, whole barley, wheat and oat plants extract about the same combined quantities of nitrogen, phosphorus, potassium and sulphur from the soil, but considerably less than canola (Table 3.4). When only the seed is removed, and all straw is left on the field, barley removes slightly more nutrients from the soil than oats but less than wheat or canola.

TABLE 3.4

NUTRIENTS USED BY CROPS (KILOGRAMS PER HECTARE)*

CROP	CROP PART	NITROGEN	PHOSPHORUS (P_2O_5)	POTASSIUM (K_2O)	SULPHUR
Wheat (3225 kg/ha or 48 bu/ac)	Seed	78	32	21	5
	Straw	32	7	64	8
	Total	111	39	85	13
Barley (3225 kg/ha or 60 bu/ac)	Seed	65	24	22	5
	Straw	34	9	73	8
	Total	99	33	95	13
Oats (3225 kg/ha or 84 bu/ac)	Seed	58	24	17	8
	Straw	40	15	70	10
	Total	98	39	87	18
Canola** (3225 kg/ha or 57 bu/ac)	Seed	120	57	29	21
	Straw	70	26	121	17
	Total	190	83	150	38

* To convert kg/ha to lb/ac, multiply by 0.89.

** Canola yield is extremely high; but to make the comparison, it was left at the same weight as the other grains.

Source: Western Canada Fertilizer Association, in Penney, D. 1998. *Fertilizer Requirements of Cereals*. Alberta Agriculture, Food and Rural Development.

Organic fertilizer is fertilizer from organic sources, including manure, compost, decaying plant matter and sewage sludge. These fertilizers add organic matter to the soil and supply needed nutrients. Organic fertilizers release nutrients slowly over several years. These fertilizers may contain pathogens that can contaminate water sources. Overapplication of these fertilizers can increase the amount of salt in the soil. Organic fertilizers may not precisely meet the crop's nutrient requirements, and so you may need to supplement an organic fertilizer application with commercial fertilizers.

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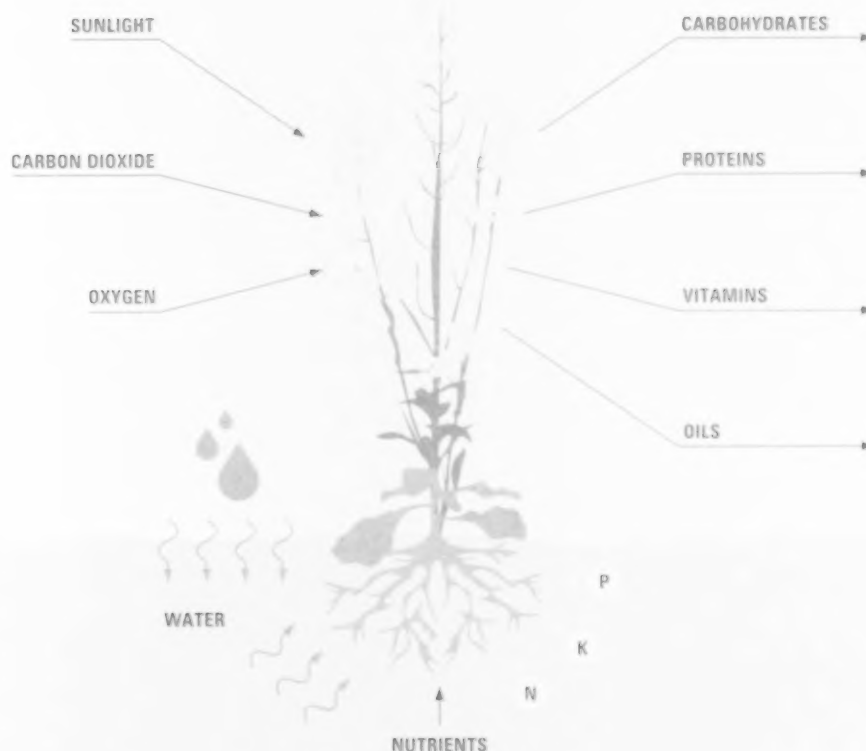
		Nitrogen	Phosphorus	Potassium	Sulphur
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	Straw	32	7	64	8
	Total	111	39	85	13
Barley (3225 kg/ha or 60 bu/ac)	Seed	65	24	22	5
	Straw	34	9	73	8
	Total	99	33	95	13
Oats (3225 kg/ha or 84 bu/ac)	Seed	58	24	17	8
	Straw	40	15	70	10
	Total	98	39	87	18
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Commercial fertilizer, also called inorganic fertilizer, is manufactured from non-renewable resources. The nutrient content of these fertilizers is known and consistent, unlike organic fertilizers. Commercial fertilizer can be applied evenly and accurately, and nutrients can be applied at the rates required by the crop.

FIGURE 3.7

GREEN PLANTS CONVERT LIGHT, WATER, AIR AND PLANT NUTRIENTS INTO FORMS USEFUL TO PEOPLE AND ANIMALS



Adapted from: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1994, Best Management Practices: Nutrient Management, Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, p. 2

Crop residues are also a source of nutrients. Retaining crop residues on the field allows part of the nutrients taken up by the crop to be returned to soil. Nitrogen fixed from the air by legume crops, especially forage legumes, can add significantly to the supply of this nutrient in soil. Residues from cereals and grasses tend to be lower in nitrogen. Because soil microorganisms require nitrogen to break down these residues, the supply of nitrogen available to crops can be temporarily reduced when large quantities of crop residues are returned to the soil.

All agricultural operators must manage nutrients in accordance with the standards in the *Agricultural Operation Practices Act* (AOPA). Your first step is to ensure that your operation meets these standards (see Section 9.1.1); BMPs take your operation beyond these basic requirements.

3.6.1 Nutrient Management Planning

Nutrient management planning aims to optimize crop yield and quality, minimize fertilizer input costs, and protect soil and water. It focuses on applying the right amount of the right product in the right place at the right time. This involves setting realistic target yields, choosing the correctly balanced blend of nutrients, placing the nutrients as close to the growing plant as possible without damaging the plant, and applying the fertilizer as close as possible to the time the plants need the nutrients.

Nutrient management planning uses a balanced fertility perspective, considering the amounts of all nutrients in the soil and the crop's requirements (Figure 3.8). Basing fertilizer recommendations on only one nutrient results in unbalanced soil fertility. Calculating and applying the appropriate amount of each nutrient is called **balanced fertility**.

FIGURE 3.8

PLANT GROWTH IS DETERMINED BY MOST LIMITING GROWTH FACTOR



Adapted from: Agriculture and Agri-Food Canada, 2000, Nutrient Management Planning: Water Quality Matters: FactSheet series.

Balanced fertility increases nutrient use efficiency, thereby reducing the risk of nutrient loss to the environment. A slight deficiency in one nutrient can affect the plant's ability to take up another nutrient. This results in unused nutrients that may be susceptible to leaching, runoff or gaseous losses. A well-fed crop produces a healthier, more extensive root system able to explore a greater

area in search of nutrients and water. This results in more efficient extraction of nutrients and water, and because a higher yield is produced with the same amount of water, crop water use efficiency is improved.

Balanced fertility management also reduces erosion potential. The crop grows faster so the soil surface is covered more rapidly. In addition, more biomass is produced so more crop residues can be left behind to protect against erosion.

The eight steps to the nutrient management planning process are:

1. Know the regulations that apply to your operation.
2. When using manure, test the manure for its nutrient content (nitrogen, phosphorus and potassium), and know the amount you will be applying.
3. Test the soil in your fields to determine nutrient levels, soil EC and soil pH.
4. Follow the soil test recommendations to meet your crop's nutrient requirements based on the soil test results, crop to be grown and expected yield.
5. When applying both manure and commercial fertilizer to a field, determine the rates of both to achieve balanced fertility.
6. If you are going to apply manure, prioritize your fields for manure application suitability (see box).
7. Calibrate your fertilizer application equipment.
8. When applying manure, take into consideration options to reduce odour nuisance for neighbours.

Prioritizing Fields for Manure Application

You may have one or more fields suitable for manure applications. It is important to consider several factors when comparing manure management options. For example, there may be some negative impacts to the environment on fields with higher nitrogen leaching or runoff potential.

The following check list provides some of the field characteristics that you should consider when selecting fields suitable for manure applications.

- * Soil test N
- * Soil test P
- * Crop N requirement
- * Leaching potential
- * Erosion potential
- * Runoff potential
- * Slope
- * Distance to water bodies

Rank each of the factors for the suitable fields with a relative ranking of low or high. Fields with a higher number of factors ranked low would get manure applied first.

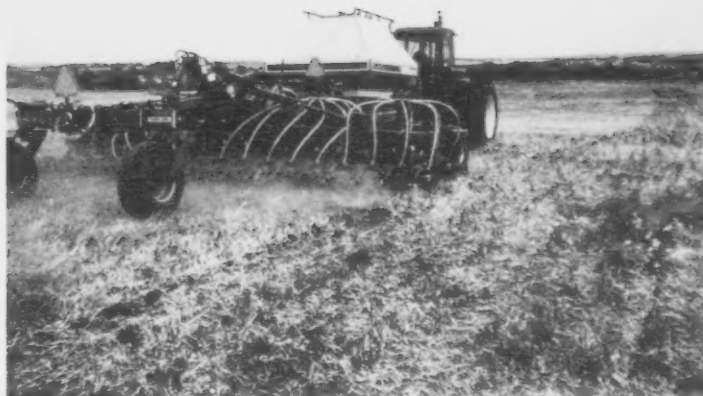
For more information, see *Nutrient Management Planning* (AAFC), *Nutrient Management Planning for Livestock Production* (AAFRD), and *Alberta Fertilizer Guide* (AAFRD).

3.6.2 Reducing Nitrogen and Phosphorus Losses

Losses of nitrogen and phosphorus from the soil through erosion, leaching or gaseous emissions can have serious environmental impacts (see Chapter 4) as well as economic impacts due to the loss of valuable crop nutrients.

BMPs to reduce losses of nitrogen and phosphorus include:

- Develop and implement a nutrient management plan.
- Soil test annually to determine the soil's nutrient levels.
- Manage the four main aspects of nutrient application – application rate, application timing, application method and nutrient form.
 1. The **application rate** is determined by taking into consideration soil test results, crop requirements and having realistic yield goals.
 - Set yield goals based on such factors as anticipated growing conditions when determining crop nutrient requirements. If the yield potential turns out to be higher than expected, you may be able to apply additional nitrogen later.
 - Based on the soil test recommendations, apply fertilizers to balance all nutrients to meet the crop's needs and anticipated moisture availability.
 - If the soil test shows excessive nitrate levels, reduce the nitrogen application rate to draw down nitrate reserves in the soil. If soil phosphorus levels are excessive, reduce phosphorus applications so crop uptake will draw down the phosphorus levels, or grow crops such as alfalfa or grass hay that remove significant amounts of phosphorus.
 - Avoid overapplication.
 2. **Application timing** is crucial to maximize efficiency and reduce potential environmental hazards:
 - When possible, apply nitrogen in the spring just before or during seeding. Avoid applying large amounts in late summer, fall or winter.
 3. The **application method** can affect nutrient use efficiency and nutrient losses.
 - Incorporate solid manure or inject liquid manure.
 - Band nitrogen to the side of the seed row, rather than broadcasting. If placing nitrogen directly in the seed row, make sure you are using rates that will not damage the seed.
 - Band phosphorus with the seed or to the side of the seed row, because of its low mobility, for efficient crop utilization. Use caution when applying high rates of phosphorus directly with the seed because these rates may cause crop damage.
 4. The **nutrient form** affects how much of the nutrient is available to the crop. Chemical and physical properties differ among commercial fertilizers. The availability of nutrients in organic nutrient sources, such as manure, is controlled by microbial processes.
- Check the fertilizer application equipment at least once per job to make sure it is working properly and is properly calibrated.
- Avoid applying nitrogen to wet areas.
- Take measures to prevent soil erosion (see Section 3.3).
- Decrease the amount of summerfallow land.
- Leave a buffer zone around lakes, streams and wells that meets or exceeds AOPAs setback requirements. Do not apply manure or commercial fertilizers to the buffer.



➡ Banding reduces losses of valuable nutrients.

Courtesy of RTL

For more information, see *Nutrient Management Planning for Livestock Production* (AAFRD) and *Nutrient Management Planning* (AAFC). Consult a professional agronomist or crop specialist for advice on nutrient management.

3.6.3 Manure Application

Manure can provide organic matter and nutrients, but it must be properly managed. Overapplication can lead to problems such as contamination of water sources with nutrients and pathogens, emission of odours and greenhouse gases, nutrient loading in the soil leading to crop lodging and lower yields, and salt accumulation resulting in poor yields.

Testing soil and manure to determine their nutrient levels is the only way to be sure about how much manure to apply. Remember that some nutrients are released only gradually from manure and other organic fertilizers.

AOPA provides regulations for manure application and storage; BMPs take your operation beyond the basic requirements set by AOPA.

BMPs for manure applications:

- ▶ Develop and implement a nutrient management plan.
- ▶ Determine manure application rate based on:
 - soil and manure tests,
 - the crop to be grown, and
 - realistic yield goals.
- ▶ Use commercial fertilizers to supplement the nutrients supplied by manure.
- ▶ Incorporate solid manure as soon as possible, preferably within 12 hours, or inject liquid manure. Incorporation considerations should include measures to reduce soil erosion.
- ▶ Check the manure spreader at least once per job to make sure it is working properly and is properly calibrated.

- » Apply manure uniformly.
- » Rank fields by their suitability for manure application.
- » Don't apply manure or other fertilizers on frozen ground.
- » Apply manure in the spring if possible.
- » Leave a buffer zone around lakes and streams, and do not apply manure or other fertilizers to the buffer.
- » Ensure that the regulations for minimum setback distances from water bodies are met (see Section 9.1.1). If site-specific conditions (such as a high runoff potential) indicate that contamination may occur with the minimum setback distance, increase the distance.
- » Compost manure and other organic fertilizers to reduce the amount of material that needs to be applied and to reduce transportation costs.
- » Monitor potassium, calcium and magnesium ratios in forage grown on manured soils to prevent grass tetany and milk fever in livestock. Watch for high nitrate levels in annual cereal greenfeed or silage on heavily manured soils. Problem feeds should be diluted to safe levels.

For more information on manure management, see *Nutrient Management Planning for Livestock Production* (AAFRD) and *Beneficial Management Practices: Environmental Manual for Feedlot Producers in Alberta* (Alberta Cattle Feeders' Association and AAFRD, http://www.agric.gov.ab.ca/livestock/beef/bmp/bmp_feedlot.html). Refer to AOPA for manure management regulations. Consult a professional agronomist or crop specialist for advice on nutrient management.

3.7 Pest Management and Pesticides

3.7.1 Integrated Pest Management

Crop pests include plants, insects, birds, mammals and diseases that reduce crop yield and/or quality. Integrated pest management (IPM) involves using a combination of control methods (cultural, biological, chemical and mechanical) in a program that is both economically and environmentally sound. IPM considers the overall management of a pest species, not just the control measures used during destructive outbreaks. The objective of IPM is to prevent pest outbreaks.

This pest management system offers a variety of advantages compared to using a single management tool to control a pest including:

- » fewer pesticide applications, resulting in more efficient use of inputs such as pesticides, fuel, water and time.
- » less potential impact on soil, water and non-target species of fish, wildlife and insects.
- » more stability in the pest complex with the potential of fewer emerging problems because competitors and beneficial species are not eliminated.
- » no loss of quality or yield in the long term.

However, IPM presents some challenges. It requires a greater understanding and long-term commitment on the part of farmers. Farmers must be willing to keep up to date with research findings and monitoring techniques, and keep complete records. On some crops, IPM principles require a more complete, longer-term focus to make economic sense. There may be some added expenses for monitoring equipment, field scouting and consultants. And IPM programs are not always easily transferred from area to area because of variations in climates and pest complexes.

IPM has four basic steps:

1. Identify the pest and use pest control methods that focus on prevention of outbreaks.
2. Monitor pest and beneficial species populations, and use economic thresholds (Figure 3.9) for implementing control measures.
3. Choose control options, implement them when thresholds indicate control is needed, and assess their effectiveness.
4. Keep records of all pertinent data and results.

FIGURE 3.9

THRESHOLD LEVELS FOR PEST CONTROL

Adapted from: Agriculture and Agri-Food Canada, 2000. Pest Management and Water Quality. Water Quality Matters. Factsheet Series.

Threshold Identification

Two pest threshold levels are identified in an IPM system. The first is the economic threshold, which occurs when pest density causes damage equal to the cost of control measures. The second is the action threshold, which is defined as the pest density when control measures should be applied. The action threshold is lower than the economic threshold to allow time for treatment to take effect.

Pest Control Methods**Cultural control:**

- ▶ Manage the crop for a vigorous, healthy stand that is better able to withstand pests.
- ▶ Choose pest-resistant varieties.
- ▶ Use rotations to reduce or eliminate the conditions the pest needs to thrive.
- ▶ Varying planting and harvest dates can help to prevent certain pest problems.

- * Eliminate materials or places where pests live and reproduce by:
 - purchasing clean, treated seed,
 - cleaning all tillage, seeding and harvesting equipment between fields,
 - removing contaminated crop residue,
 - removing nearby plant species that can act as alternate hosts for diseases or insects.
- * Use trap strips to draw the pest's attention away from the crop (see box).
- * If possible, leave strips of a forage or hay crop standing when harvesting (called strip harvesting). This will prevent the migration of pests to another field, preserve natural enemies of pests and improve snow management.

Biological control

- * Use an introduced agent (insect, pathogen) to control the pest.
- * Introduced pest has to be established in sufficient numbers to be effective.
- * Avoid pesticides that will kill the introduced agent.

Mechanical control

- * Mowing, tilling, grazing and hand pulling can be used to control weeds.
- * Silage weedy fields to stop the weeds from going to seed.

Chemical control

- * Select and apply pesticides according to label instructions to minimize harmful effects on non-target species and to reduce environmental hazards (see Section 3.7.2).

Trap Strips

Trap strips are strips of crops grown around the main crop to draw insects away from the main crop. The pest can be more easily controlled while it is contained in a concentrated strip.

Typically the timing of the trap crop's growth cycle is somewhat different from that of the main crop. For example, a strip of Polish canola can be seeded around the outside of an Argentine canola crop to control cabbage seedpod weevils. Polish canola blooms earlier so its flowers attract the weevils to the trap strip.

For more information, see *Integrated Pest Management in Canada: A Directory of Expertise* (AAFC), *Natural Enemies of Pests Associated with Prairie Crops* (AAFC) and *Using Cultural Practices to Reduce Pest Problems in Crops* (AAFRD).



➡ Trap strips draw insects away from the main crop.

Courtesy of Agriculture and Agri-Food Canada, Lethbridge

3.7.2 Pesticide Application

Producers have the legal right to apply pesticides on their property provided that the pesticide application does not contravene any bylaws, regulations or generally accepted practices.

Producers have the legal responsibility to ensure that any pesticide application performed on their property does not cause harm to adjacent properties or people. When using custom applicators, ensure that applicators are certified. Also ensure that the applicator is aware of potential hazards in advance of an application.

If pesticides are part of your integrated pest management plan, follow these practices:

Deciding if pesticides are needed

- ✦ Use timely and regular field scouting to accurately assess your pest problems and to assess economic threshold levels, so you can apply pesticides only when they are needed.

Determining application rates

- ✦ Apply pesticides according to the label instructions. Avoid overapplication.

Selecting pesticides

- ✦ Do not use persistent herbicides on flood-prone or sandy soils.
- ✦ Rotate chemical groups to prevent the development of resistant pest populations.

Minimizing transport of pesticides off the field

- ✦ Reduce movement of pesticides attached to soil particles through measures that control wind and water-soil erosion such as maintaining a crop residue cover, growing shelterbelts and establishing grassed waterways (Table 3.5).
- ✦ Leave wide buffer zones around environmentally sensitive areas, including streams, rivers, wells and dugouts. As a minimum, these zones should meet all buffer width regulations.

- Avoid irrigating soon after a pesticide application. Check the product label for details.
- Avoid applying pesticides if rain is expected soon.
- Do not wash spray equipment in a water body or move this equipment through a water body.

Reducing spray drift

- Reduce sprayer travel speed, lower the boom, use shrouds and/or use a properly adjusted air assist to reduce the risk of spray drift.
- Increase droplet size to reduce spray drift. Use spray nozzles that deliver a larger droplet size, lower the spray boom, and avoid spraying in high temperatures or low relative humidity.
- Create less drift-prone sprays by reducing pressure, increasing carrier volume, using low drift nozzles or using a drift-reducing adjuvant.
- Stop application when wind speeds are above 16 to 20 km/h.
- Check pesticide labels for wind speed limits to avoid spray drift.
- If you must spray near environmentally sensitive areas, such as water sources, neighbours' yards and shelterbelts, spray when the wind is blowing away from them.
- Use a buffer zone to capture the major portion of drifted droplets to minimize risk to adjacent areas.
- Avoid spraying during a temperature inversion (see Section 2.7.3).
- Avoid spraying volatile products on or just before hot days to decrease vapour drift.

TABLE 3.5

LOSS POTENTIALS OF SOME COMMON AGRICULTURAL CHEMICALS

PESTICIDE	RUNOFF POTENTIAL*	LEACHING POTENTIAL
Banvel	Small	Large
Basagran	Small	Medium
2,4-D Amine	Medium	Medium
Lexone, Sencor	Medium	Large
Linuron	Large	Medium
Poast	Small	Small
Roundup	Large	Small
Treflan	Large	Small
Counter	Medium	Small
Dyfonate	Large	Medium
Bayleton	Medium	Medium
Tilt	Medium	Medium

* Runoff potential: potential for transport of pesticide in runoff water.

Source: Agriculture and Agri-Food Canada and Ontario Ministry of Agriculture and Food, 1992. *Best Management Practices: Field Crop Production*. Agriculture and Agri-Food Canada, and Ontario Ministry of Agriculture and Food.



➡ Reduce spray drift damage by using low drift nozzles or using a drift-reducing adjuvant.

Courtesy of Agriculture and Agri-Food Canada – Tom Wolf and AgTech Centre – AAIRD

For more information, see the latest edition of AAIRD's *Crop Protection* manual (the 'blue book'), *How Herbicides Work: Biology to Application* (AAIRD) and *Pesticide Drift Management* (Alberta Environmental Protection).

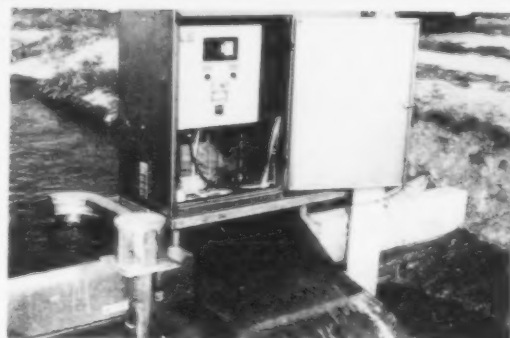
3.8 Irrigated Crop Production

Environmental considerations in irrigation farming include ensuring the efficient use of water and preventing soil salinity and associated drainage problems that can be caused by canal seepage, poor water management and poor irrigation practices.

On a farm level, irrigation water management involves the determination and control of the rate, amount and timing of irrigation water in a planned and efficient manner. The purpose of irrigation management is to effectively use the available water supply in managing and controlling the moisture environment of crops to promote the desired crop response, minimize soil erosion and protect water quality. Proper irrigation management requires a good understanding of soil, crop and climatic properties that affect soil water movement and storage, and crop water use. This knowledge leads to the development of workable and efficient irrigation schedules.

3.8.1 Water-efficient Equipment

Irrigation systems have become more efficient in recent decades, reducing water losses through deep percolation, runoff, evaporation and wind drift. Some of these advances have also improved energy efficiencies.



⇒ Irrigation systems are more efficient reducing water losses through deep percolation, runoff, evaporation and wind drift.

Courtesy of AAFRD - Irrigation Branch

The most water-efficient systems are pivot or lineal move systems with drop tubes and low pressure spray nozzles that are designed to meet crop and soil requirements. Drip systems or other similar systems apply water to the plant rooting area only. Efficiencies of surface irrigation systems have been improved through use of gated pipe, surge valves and siphon tubes and other measures to reduce water use and runoff.

Beneficial management practices for irrigation equipment include:

- Choose a water-efficient system, or upgrade your current system to reduce water losses, energy costs and environmental costs. Water losses result in increased runoff and increased movement of nutrients, sediments and other substances into water sources, harming water quality and aquatic habitats. As well, nutrient losses represent wasted input costs.
- Ensure your irrigation system is properly designed and sized for your operation.
- Conduct regular maintenance checks, and make needed repairs such as stopping leaks and replacing worn nozzles.
- Investigate options for upgrading your system about every five to 10 years.

Within an irrigation district, canal maintenance is the responsibility of that irrigation district. With assistance from the Alberta and Canadian governments, Alberta's Irrigation Districts are replacing, relocating, and lining canals on an ongoing basis to eliminate seepage and improve water delivery efficiency.

3.8.2 Irrigation Applications

Appropriate timing and amounts of irrigation water improve crop yields and decrease the amount of water lost to percolation and runoff. Reducing water loss improves water efficiency, minimizes the risk of nutrient losses, soil salinity, drainage problems, and keeps operating costs down.

Beneficial management practices for irrigation applications include:

- Select crops suited to your local soil and climate, choose healthy seed, and fertilize to meet the crop's needs.
- Know how much plant-available water your soil can hold at field capacity and then irrigate to 90% of the capacity, while leaving 10% for possible rainfall. Use the texture-based guide in Table 3.6.
- Learn about the water needs of your specific crop variety. Water requirements depend on the crop type, variety and stage of growth, target yield and crop management.
- Use irrigation scheduling to ensure that soil moisture is kept sufficiently high to promote active plant growth, while avoiding unnecessary water applications.
- To prevent runoff, ensure that the irrigation application rate is equal to or less than the soil's infiltration rate (Table 3.6).
- Fertilize according to the soil test recommendations to ensure that soil fertility does not limit the crop's ability to use water efficiently.
- Use computer software and weather data to continuously adjust your irrigation schedule.
- Monitor soil moisture on a weekly basis. Monitoring options include soil moisture sensors, crop water use models, direct measurement of crop use, or the feel method.
- Monitor and record water application rates and volumes.
- Avoid irrigating soon after pesticide or fertilizer applications. Check product label for details.

Land must be assessed as to its suitability for irrigation prior to irrigation development within or outside of an irrigation district. Land classification for irrigation is required: a) as input to an agriculture feasibility report to obtain a water licence for irrigation development outside an irrigation district; and b) to obtain a water right for irrigation development within an irrigation district. Only land classified as suitable for irrigation can be granted a licence or water right for irrigation in Alberta. The economic risk and risk of on-site and off-site environmental impacts are reduced by irrigating only those lands that are suited to irrigation.

TABLE 3.6

PLANT-AVAILABLE WATER AND INFILTRATION RATE BASED ON SOIL TEXTURE

SOIL TEXTURE	PLANT-AVAILABLE MOISTURE IN 1-M ROOT ZONE		BASIC INFILTRATION RATE WHEN SOIL IS SATURATED
	(mm)	(in)	(mm/h)
Loamy Sand	112	4.4	26 - 60
Sandy Loam	140	5.5	25.6
Loam	180	7.0	6.8
Sandy Clay Loam	152	6.0	4.3
Silt Loam	200	8.0	13.2
Clay Loam	200	8.0	2.3
Silty Clay Loam	220	8.7	1.5
Sandy Clay	172	6.8	1.2
Silty Clay	212	8.3	1.0
Clay	192	7.6	0.6

Adapted from: Alberta Agriculture, Food and Rural Development, 2000. Procedures Manual for the Classification of Land for Irrigation in Alberta. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta.

For more information, visit your AAFRD irrigation specialist for individual irrigation management recommendations, the Alberta Irrigation Management Model software, and publications. AAFRD's website has irrigation information, climate and weather data, and a list of trained land classification consultants.

3.9 Managing for Special Conditions

3.9.1 In-field Variation

Site-specific management or precision farming is the practice of tailoring farm inputs according to differences in growing conditions within farm fields. It offers the potential to increase economic efficiency and reduce environmental impacts. For example, a uniform fertilizer rate results in overapplication in areas where yields are limited by other factors, such as on eroded knolls, and in areas where nutrient levels are already high. Overapplication increases the risk of nutrient losses to the environment and such problems as crop lodging. Site-specific management allows producers to apply inputs only where they are needed.

Site-specific management can also be used to limit inputs in areas prone to loss of that input. An example is reducing nitrogen applications to low-lying areas that are periodically saturated. In wet conditions, nitrogen is easily lost to the atmosphere as nitrous oxide, a greenhouse gas, harming the environment and reducing the nitrogen available to the crop.

There are many inexpensive tools to aid site-specific management. These include soil sampling at benchmark locations to represent different site conditions (see Section 3.1.1), air photo interpretation to identify the extent of different soils or landform units that should be managed differently, and variable rate controllers to change input rates.

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Clay	192	7.6	0.6

Adapted from: Robert S. Steinberg, *Practical Farm Irrigation*, 2000. Reprinted: *Manual for the Irrigation of Crops in the Northwest*, Alberta, 2000. (Reprinted with permission of the University of Alberta, 2000.)

For more information, visit your AAIRD irrigation specialist for individual irrigation management recommendations, the Alberta Irrigation Management Model software, and publications. AAIRD's website has irrigation information, climate and weather data, and a list of trained land classification consultants.

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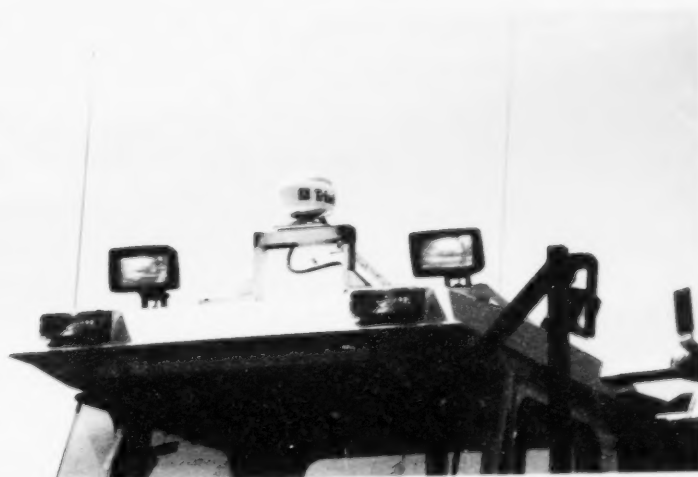
There are many inexpensive tools to aid site-specific management. These include soil sampling at benchmark locations to represent different site conditions (see Section 3.1.1), air photo interpretation to identify the extent of different soils or landform units that should be managed differently, and variable rate controllers to change input rates.

More costly options include global positioning system (GPS) tools to locate soil and yield sample areas, yield monitors to measure yield variation, and geographic information system (GIS) software and other software tools to map crop and soil information. Whether these tools are economically justified will depend on the specifics of your operation.



➡ Yield map showing yield variation within a sample field.

Courtesy of AAFRD



➡ Tractor mounted with GPS to locate soil and yield sample areas.

Courtesy of AgTech Centre - AAFRD

For more information, see PFRA's *Questions and Answers on Precision Farming*.

3.9.2 Saline Soils

Agricultural practices can play a role in increasing or decreasing saline seeps. Practices to manage soil salinity include:

- › Test soil samples from the area suspected of having excess salts to determine whether you have saline, saline-sodic, sodic soils or some other condition (see Section 2.3).
- › Contact a soil specialist to identify existing and potential recharge areas and to develop a plan for controlling salinity.
- › In recharge areas:
 - Use deep-rooted, high-moisture-use crops like alfalfa. These crops help dry out the subsoil and lower the water table so less water and salt move from the recharge area to the discharge area.
 - Avoid summerfallowing these areas.
 - Use grassed waterways to remove excess water.
 - Use snow management to evenly distribute snow and prevent ponding in the spring.
- › In discharge areas:
 - As much as possible, have growing plants in the discharge area to help lower the water table. Use continuous cropping if possible (see Table 2.2), or convert the area to permanent cover with salt-tolerant grasses (see Table 3.7).
 - Consider using subsurface (tile) drainage systems to remove water and salts from the seep. Although subsurface drainage is expensive, not suited to all salinity types and requires engineering design, it will lower water tables in seeps if the conditions are right, and the system is properly designed, installed and managed.
 - Avoid applying manure to this area because manure contains salts.
- › Monitor the extent and intensity of the saline areas over time. If they continue to grow, consider increasing control measures. For example, convert a greater portion of the land around the recharge area into deep-rooted perennial forages.

TABLE 3.7

GRASS SPECIES RECOMMENDED FOR SEEDING INTO SALINE SEEPS

SPECIES	SEEDING RATE (kg/ha)	RATE OF ESTABLISHMENT	SOD OR BUNCH	SALINITY TOLERANCE*	LONGEVITY	WINTER HARDINESS	FLOODING TOLERANCE	DROUGHT TOLERANCE
Creeping Foxtail	5 - 10	Average	Sod	High	Long	Good	High	Poor
Meadow Foxtail	5 - 10	Average	Sod	Medium	Long	Good	High	Poor
Smooth Bromegrass	5 - 10	Slow	Sod	Medium	Long	Excellent	Medium	Good
Meadow Bromegrass	5 - 10	Slow	Sod	Medium	Long	Excellent	Medium	Good
Slender Wheatgrass	5 - 10	Very Fast	Bunch	High	Short	Good	Medium	Good
Intermediate Wheatgrass	5 - 10	Fast	Sod	Medium	Short	Excellent	Medium	Good
Pubescent Wheatgrass	5 - 10	Fast	Sod	Medium	Short	Excellent	Medium	Good
Tall Wheatgrass	5 - 10	Fast	Bunch	High	Long	Excellent	High	Poor
Western Wheatgrass	5 - 10	Fast	Sod	High	Long	Excellent	High	Good
Russian Wildrye	5 - 10	Very Slow	Bunch	High	Long	Good	Poor	Good
Altai Wildrye	5 - 10	Very Slow	Bunch	High	Long	Excellent	Medium	Good
Beardless Wildrye	5 - 10	Very Slow	Sod	Very High	Long	Good	Medium	Good
Nuttall's Alkali Grass	5 - 10	Average	Sod	Very High	Long	Good	Medium	Good

* Salinity tolerance: medium (tolerates up to 6 dS/m), high (tolerates up to 8 dS/m), very high (tolerates greater than 12 dS/m).

Source: Wright D. 1996. *Perennial Crops for Salinity Control in Discharge Areas: Alberta Agriculture Food and Rural Development, Agdex 512-1*.

For more information, see *The Health of Our Soils* (NAFC), *Perennial Crops for Recharge Control of Saline Seeps* (NAFRD), *Perennial Crops for Salinity Control in Discharge Areas* (NAFRD), and *Structural Controls for Dryland Saline Seeps* (NAFRD).

3.9.3 Acid Soils

Acid soils can occur naturally or as a result of the long-term use of nitrogen fertilizers. To manage these soils, follow these guidelines:

- » Sample and soil test to find out the extent and severity of soil acidity, determine the rate of lime required, and obtain an estimate of crop response to lime. Divide the field into areas on the basis of soil type or differences in crop growth and sample each of these areas separately.
- » Apply lime to neutralize excess acidity and raise pH levels (Table 3.8). Some areas of a field may require higher rates than others, and some areas may not require any.
- » Grow acid-tolerant crops (see Section 2.4).
- » Avoid overapplication of nitrogen. Avoid extensive use of ammonium sulphate (21-0-0-24) on acid soils; it has greater acidifying properties compared to other nitrogen fertilizers.

TABLE 3.8

EFFECTS ON CROPS OF LIMING ACID SOILS

RATING	SOIL PH	DIRECT EFFECTS OF LIMING ON CROPS
Slightly Acid	6.1 to 6.5	No direct effect on most crops. Fields with an average pH just above 6.0 may have areas where the pH is below 6.0. Alfalfa and sweet clover yields will be increased on the more acid areas.
Moderately Acid	5.6 to 6.0	Survival and growth of <i>Rhizobium</i> bacteria, which fix nitrogen in association with alfalfa and sweet clover, are improved. Yields of alfalfa and sweet clover are increased. Small increases in barley yields occur in the first two or three years following lime applications with larger increases (25 to 30%) occurring in subsequent years. Yields of wheat and canola are increased less than barley yields. Yields of more acid-tolerant crops may be increased as a result of indirect effects of liming (such as improved physical properties of some soils and improved phosphorus availability).
Strongly Acid	5.1 to 5.5	Nitrogen fixation and yields of legumes are increased. Soluble aluminium and manganese are reduced to non-toxic levels. Yields of most crops are increased as a result of reduced levels of aluminum and manganese, and improved availability of phosphorus and other nutrients.
Very Strongly Acid	Less than 5.1	Same effects as for strongly acid soils. Yields of most crops are severely reduced unless the soil is limed. Very strongly acid soils are very infertile. Acid-tolerant crops (oats and some grasses) do moderately well if adequately fertilized.

Adapted from: Parney, B. 1998. *Liming Acid Soils*. (Illinois Agriculture, Food and Rural Development, Series 334-1)

For more information, see *Liming Acid Soils* (AAFRD).

TABLE 3.7

GRASS SPECIES RECOMMENDED FOR SEEDING INTO SALINE SEEPS

Species	Seeds per Acre (lb)	Rate of Establishment	Soil Salinity Tolerance	Height	Rooting Depth	Stolon	Seedling Height	Seedling Width	Seedling Length	Seedling Weight
Creeping Foxtail	5 - 10	Average	Sod	High	Long	Good	High	High	Poor	Poor
Meadow Foxtail	5 - 10	Average	Sod	Medium	Long	Good	High	High	Poor	Poor
Smooth Bromegrass	5 - 10	Slow	Sod	Medium	Long	Excellent	Medium	Medium	Good	Good
Meadow Bromegrass	5 - 10	Slow	Sod	Medium	Long	Excellent	Medium	Medium	Good	Good
Slender Wheatgrass	5 - 10	Very Fast	Bunch	High	Short	Good	Medium	Medium	Good	Good
Intermediate Wheatgrass	5 - 10	Fast	Sod	Medium	Short	Excellent	Medium	Medium	Good	Good
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Russian Wildrye	5 - 10	Very Slow	Bunch	High	Long	Good	Poor	Poor	Good	Good
Altai Wildrye	5 - 10	Very Slow	Bunch	High	Long	Excellent	Medium	Medium	Good	Good
Beardless Wildrye	5 - 10	Very Slow	Sod	Very High	Long	Good	Medium	Medium	Good	Good
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For more information, see *The Health of Our Soils* (AMC), *Perennial Crops for Recharge Control of Saline Seeps* (AMRD), *Perennial Crops for Salinity Control in Discharge Areas* (AMRD), and *Structural Controls for Dryland Saline Seeps* (AMRD).

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Apply lime to neutralize excess acidity and raise pH levels (Table 3.8). Some areas of a field may require higher rates than others, and some areas may not require any.

Grow acid-tolerant crops (see Section 2.4).

Avoid overapplication of nitrogen. Avoid extensive use of ammonium sulphate (21-0-0-24) on acid soils; it has greater acidifying properties compared to other nitrogen fertilizers.

TABLE 3.8

EFFECTS ON CROPS OF LIMING ACID SOILS

Soil pH	Range	Effects on Crops
Slightly Acid	6.1 to 6.5	No direct effect on most crops. Fields with an average pH just above 6.0 may have areas where the pH is below 6.0. Alfalfa and sweet clover yields will be increased on the more acid areas.
Moderately Acid	5.6 to 6.0	Survival and growth of <i>Rhizobium</i> bacteria, which fix nitrogen in association with alfalfa and sweet clover, are improved. Yields of alfalfa and sweet clover are increased. Small increases in barley yields occur in the first two or three years following lime applications with larger increases (25 to 30%) occurring in subsequent years. Yields of wheat and canola are increased less than barley yields. Yields of more acid-tolerant crops may be increased as a result of indirect effects of liming (such as improved physical properties of some soils and improved phosphorus availability).
Strongly Acid	5.1 to 5.5	Nitrogen fixation and yields of legumes are increased. Soluble aluminium and manganese are reduced to non-toxic levels. Yields of most crops are increased as a result of reduced levels of aluminum and manganese, and improved availability of phosphorus and other nutrients.
Very Strongly Acid	Less than 5.1	Same effects as for strongly acid soils. Yields of most crops are severely reduced unless the soil is limed. Very strongly acid soils are very infertile. Acid-tolerant crops (oats and some grasses) do moderately well if adequately fertilized.

Source: Adapted from *Liming Acid Soils*.

For more information, see *Liming Acid Soils* (AAIRID).

3.9.4 Peat Soils

Peat soils, sometimes called organic soils, occur in the cooler and wetter areas of Alberta. Peaty areas are often located in low, wet spots within normal fields.

Peat soils are highly variable in acidity and fertility. There are two main types of peat soils: bog peatland and fen peatland. Bog peatland (or moss peat) is very acidic (pH lower than 5.5) and has low fertility. They are not recommended for agricultural development. Fen peatland (or sedge peat) is less acidic (pH 5.5 to 7.5) and has higher plant-available nitrogen, phosphorus and potassium than bog peatland. Fen peatland is considered suitable for agriculture. However, bog and fen peatland soils often occur together.

In most cases, forages are the best crop option for peat soils. Choose forage crops that tolerate peaty soils such as timothy, creeping foxtail, reed canary grass, and meadow foxtail.

For more information, see *Management of Organic Soils* (AAFRD), *Establishing Perennial Hay and Pasture Crops* (AAFRD) and *Farm Enterprise Information: Crop Production – Management*.

3.9.5 Solonetzic Soils

Solonetzic soils have a tough, impermeable hardpan horizon from 5 to 30 cm (2 to 12 in.) or more below the surface. This hardpan severely restricts root and water penetration, resulting in poor growth and low tolerance to drought. Compared to other soils, Solonetzic soils generally have much greater in-field variation in topsoil depth, pH, fertility and in subsoil characteristics, increasing the difficulty of managing these soils.



➡ Solonetzic hardpan horizons restrict root and water penetration.

Courtesy of AAFRD



► Irregular crop growth pattern to due to presence of Solonchic soils.

Courtesy of AAFRD

Test soil samples from the area suspected of having Solonchic soils to ensure that the problem is correctly identified. If the soils are Solonchic, the best option is to keep them under a permanent cover of trees, shrubs or pasture. If the land is in pasture, use a well managed rotational grazing system to avoid overgrazing.

If you wish to grow crops on these soils, consult an agronomist. Although deep plowing and subsoiling can make some Solonchic soils more productive for cropping, not all Solonchic soils benefit from these practices.

For more information, see *Management of Solonchic Soils* (AAFRD).

3.9.6 Soil Compaction

The dense structure and low porosity of compacted soils restrict the growth of plant roots and limit the plant's ability to obtain water and nutrients.

To prevent or minimize soil compaction:

- Avoid field work when the soil is wet.
- Try to avoid driving over the same area repeatedly.
- Use practices that add organic matter to the soil (see Section 2.1).
- Use tillage practices that minimize the disturbance of soil (see Section 3.2). Avoid the use of tillage implements that pulverize soils.
- Reduce axle weight and use flotation tires.



→ Use of flotation tires helps prevent or minimize soil compaction.

Courtesy of AAFC

For more information, see *The Health of Our Soils* (AAFC) and *Solving the Wheel Track Dilemma in Direct Seeding* (AAFC).

3.9.7 Marginal Crop Lands

Marginal crop lands are lands with characteristics that severely limit annual crop production. They include land that is very prone to erosion or flooding, land with steep slopes or rocky soils. For both economic and environmental reasons, these lands are better kept under some form of permanent cover such as perennial forages, pasture or trees.



→ Well managed woodlots provide a diversity of timber products.

Courtesy of Agriculture and Agri-Food Canada / PFRA

Before you remove natural permanent cover from an area, contact an agronomist for technical assistance in determining the agricultural potential of the land. It may be more profitable to leave the land with its natural cover.

If an attempt has already been made to convert marginal lands to annual crop production, it is best to replant them to a form of permanent cover.

3.10 Information Sources

3.10.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- * Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- * Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada by phone or visit the PFRA website (www.agr.gc.ca/pfra)
- * Your local agricultural service board
- * Reduced Tillage LINKAGES: phone: 1-780-422-7922; website: <http://reducedtillage.ca>
- * Alberta Environment: phone: 1-780-944-0313; website: <http://www3.gov.ab.ca/env/>
- * Alberta Irrigation Projects Association: phone: 1-403-328-3063; website: www.aiipa.org
- * Canola Council of Canada: website: www.canola-council.org
- * Cows and Fish Program (the Alberta Riparian Habitat Management Program), phone: 1-403-381-5538; website: <http://www.cowsandfish.org/index.html>
- * Ducks Unlimited Canada, phone: 1-780-489-2002; website: <http://www.ducks.ca/index.html>
- * Woodlot Association of Alberta: phone: 1-800-871-5680; website: <http://www.woodlot.org/>
- * Alberta Environmental Farm Plan: phone: 1-866-844- 2337 (toll-free); website: www.albertaefp.com

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CHAPTER 4.0

Storage, Handling and Disposal of Agricultural Inputs

This chapter outlines beneficial management practices for the storage, handling and disposal of pesticides (herbicides, fungicides, insecticides, rodenticides and pesticide-treated seed), commercial fertilizers, manure, petroleum products and treated seed.

Agricultural inputs include pesticides, commercial fertilizer, manure, and petroleum products. All products should also be stored in a safe and secure manner, handled to prevent contamination of water and air, and disposed of properly according to the environmental regulations.

Protective clothing and equipment are vital for anyone handling agricultural chemicals. See AAFRD's *Crop Protection* manual (the 'blue book') for more information.

4.1 Pesticides

Pesticides used in crop production include herbicides, fungicides, insecticides, rodenticides and pesticide-treated seed. Improper storage and handling of pesticides can contaminate soil, water and air and can harm humans, animals and plants. Always follow proper procedures and precautions. Some producers choose to use custom applicators for pesticide applications.

4.1.1 Storage

No pesticide should be stored on the farm. Order only the amount needed and use it immediately. If you cannot use it immediately then have it stored by the supplier. Suppliers are set up to handle the product as a hazardous good. This eliminates the liability of accidents.

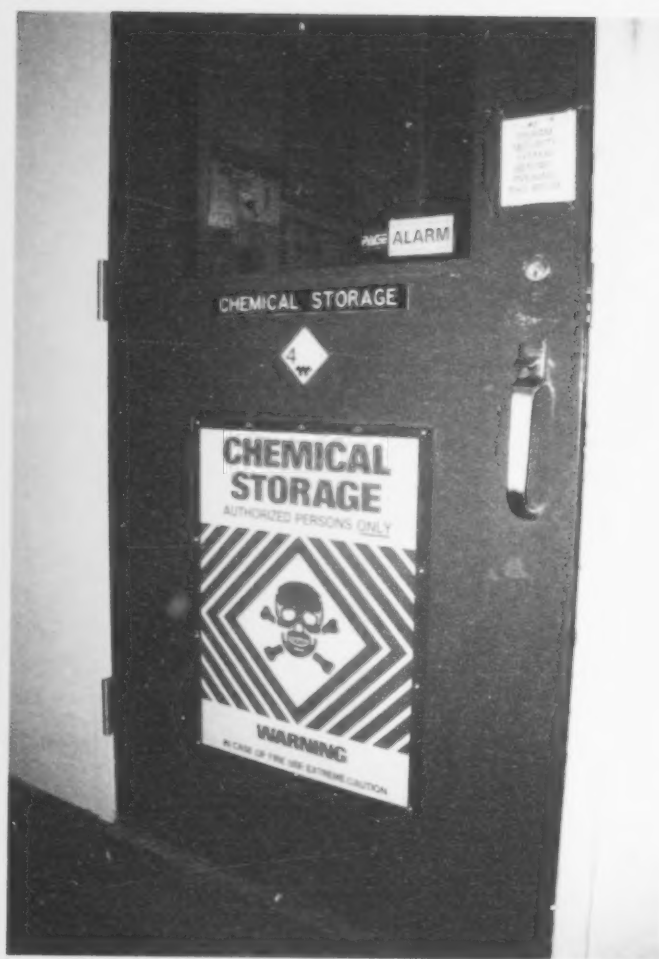
If you must store a pesticide on the farm, follow the guidelines below.

Product Storage

- ▶ The amount stored must be less than 20 L or 20 kg of product (under the *Environmental Protection and Enhancement Act*). Storage time should not exceed one month.
- ▶ Consult the pesticide's label for specific storage instructions.
- ▶ Store the pesticide in the original containers with the manufacturer's labels; if supplementary containers are used, make sure they are properly labelled.
- ▶ Do not store with food, feed, seed, drinking water or protective equipment.
- ▶ If a product container is leaking, **overpack** the container by packing it in a larger container with leak collection material (such as kitty litter).
- ▶ As a precaution, use **secondary containment** made of an impermeable material to contain possible leaks. For example, store chemical jugs in tubs or trays on storage shelves.

Storage Facility

- ▶ Store pesticides in a secure facility, and post signs indicating the contents of storage.
- ▶ Locate the facility more than 30 m (100 ft) from a surface water body and more than 90 m (300 ft) from a water well.
- ▶ Locate the facility downslope and downwind from any water sources.
- ▶ Ensure the facility is constructed to contain spills and minimize or eliminate the potential of contaminating soil and water.
 - Install an impermeable floor (e.g. sealed concrete).
 - Use curbs to contain leaks.
- ▶ Do not have a floor drain. If there is a drain, use a proper holding tank for drainage collection, monitor the tank regularly, and dispose of the fluid in the tank in accordance with hazardous waste regulations.



➡ Store pesticides in a secure facility with posted signs.

Courtesy of AAFRD

Emergency Plan

Prepare an emergency plan in case of a leak or spill at the storage site or when handling. This written plan should include the location of emergency equipment, emergency telephone numbers, cleanup methods and steps to follow.

Make sure the following materials for spill cleanup are readily available:

- ▶ absorbent material (such as kitty litter)
- ▶ shovel
- ▶ waste container
- ▶ protective equipment – rubber gloves, rubber boots

4.1.2 Mixing and Loading

When mixing and loading pesticides into the sprayer, it is inevitable that a spill will occur some day. Using proper procedures and precautionary methods will minimize or eliminate the risk of contamination.

Mixing Location

- ▶ Any mixing and loading areas must be more than 30 m (100 ft) from a surface water body and more than 90 m (300 ft) from a water well.
- ▶ The best option is to mix and load pesticides in the field near the application site. For this option:
 - Change the location of the mixing and loading site with each application.
 - Bring the water to the site in a nurse tank.
- ▶ If you are mixing at a permanent site:
 - Make sure the mixing and loading area can contain spills and drips. It should be able to contain 125% of the sprayer's tank volume. Install an impermeable floor and curbs to contain product. Install a sump to collect product.
 - Cover the mixing pad to eliminate increased volumes of contaminated water from run-on water and precipitation, or design the area to contain these larger volumes.



- ➡ Using proper procedures and protective clothing will minimize or eliminate potential risk of contamination.

Courtesy of AAFRD

Loading

- ✦ Do not leave filling equipment unattended. Have someone in control of the filling operation for the entire time.
- ✦ Have spill containment and cleanup equipment on hand. Have a phone available for emergency calls.
- ✦ To prevent backflow from the sprayer to the water source:
 - Fill the sprayer from a nurse tank away from wells or other bodies of water.
 - Never place a hose into the sprayer below the water line. Leave a minimum 6-inch (15-cm) gap between the hose and the water.
 - Install backflow preventer devices on all water pipes leading to the storage area and the pad.
 - Spray equipment must be fitted with an effective backflow preventer to be permitted to take public surface water (refer to the *Environmental Protection and Enhancement Act*).

Cleaning Field Equipment

- ✦ Wash the spraying equipment at different locations to prevent chemical buildup in the field.
- ✦ When changing pesticide products, clean out the tanks with water to ensure no product contamination occurs.
- ✦ If possible, rinse the tank in the field, and apply the rinse water (called rinsate) directly to crop. If you cannot apply it to the crop, then:
 - apply it on land away from surface water, water wells, septic systems, gardens, shelterbelts and other environmentally sensitive areas, or
 - use it as mix water for later applications when the same chemical is being applied, or
 - apply it on areas requiring total vegetation control (e.g. chemfallow).

Pesticide Transportation

Pesticides should be secured during transportation. They should not be transported with food, feed, household furnishings, toiletries, clothes, bedding or similar items.

4.1.3 Disposal

Pesticide Disposal

Pesticides are hazardous wastes and cannot be disposed of in sanitary landfills or by burning. To dispose of pesticides:

- ✦ Return unopened and leftover product to the dealer for a refund.
- ✦ If you are unable to use opened pesticide supplies, offer them to neighbours.
- ✦ Pesticides that have no further use must be disposed of as hazardous waste. The names of companies licensed to handle hazardous waste can be obtained from Alberta Environment's Recycle Information Line at 1-800-463-6326.

Pesticide Container Disposal

Empty pesticide containers must be disposed of carefully. Unrinsed empty pesticide containers have the potential to contaminate groundwater and surface water, and can be toxic to fish and wildlife.



Empty pesticide containers must be disposed of at a pesticide container disposal site.

Courtesy of Alberta Environment

Under Alberta's *Environmental Protection and Enhancement Act*, non-refillable plastic or metal pesticide containers (restricted agricultural and industrial products) must be disposed of at a pesticide container collection site. A list of pesticide container disposal sites and their hours is available from each municipality, in *Crop Protection* (AAFRD) or from Alberta Environment.

Pesticide containers must be triple rinsed or pressure rinsed and dry before they are delivered to the pesticide container site. For details on rinsing, consult *Crop Protection* (AAFRD).

Paper and cardboard outer wrappings that have not been contaminated with pesticides can be recycled at a recycling centre. Any cardboard that has been contaminated due to a container rupture, accidental spill, or improper handling procedure, should be taken to a sanitary landfill. Evidence of cardboard contamination includes signs of exposure to liquid, powder or granules, or a strong chemical odour. Some pesticide container sites have bins or separate areas for collecting outer packaging materials. Do not burn paper bags or cardboard containers. Containers should not be reused, and empty containers should be made unsuitable for reuse.

For more information on pesticide storage, handling and disposal, see *Crop Protection* (AAFRD). For specific information on the disposal of product or cleanup of spills, contact Alberta Environment's Environmental Response Centre at 1-800-222-6514.

4.2 Commercial Fertilizers and Manure

4.2.1 Storage

Fertilizers and manure need to be stored safely to avoid hazards to people, animals and the environment.

Amount Stored

The best approach is to store only the amount of fertilizer you need for your immediate use. This reduces the risk of a major spill or other accident. If product needs to be stored, it is recommended that it be secured in a strong, stable, dry structure with a good roof and a cement floor, where moisture, rain and surface water cannot enter.

Storage Facility

- ▶ Ensure that the storage facility is secure. This means a locked fenced area, locked building or storage structure separate from all other activities that could damage the containers or spill fertilizer.
- ▶ Post signs stating the contents of the facility in case of fire.
- ▶ Ensure that the facility is located more than 100 m (330 ft) from water wells and more than 20 m (60 ft) from surface water bodies.
- ▶ Do not store fertilizers with fuel, food, feed, seed, drinking water or protective equipment to prevent contamination of these.
- ▶ Monitor the storage site regularly for leaks and spills.

Emergency Plan

Prepare an emergency plan in place in case of a leak or spill. This written plan should include the location of emergency equipment, emergency telephone numbers, cleanup methods and steps to follow.

Dry Fertilizer Storage

Dry fertilizer should be stored in a building or epoxy-lined bin on an impermeable surface such as sealed concrete.

Liquid Fertilizer Storage

- ▶ Regularly inspect all tanks, valves and plumbing used for liquid fertilizer storage.
- ▶ Around the primary storage container, install an impermeable synthetic or clay liner for secondary containment to stop any spills and leaks from entering soil or water.
- ▶ Use sight gauges and lock-on valves on containers.



- ➡ Commercial fertilizers need to be stored safely to avoid hazards to people, animals and the environment.

Courtesy of AAFRD

Manure Storage and Treatment

For information on manure storage and treatment, see:

- *Nutrient Management Planning for Livestock Production* (AAFRD)
- *Beneficial Management Practices: Environmental Manual for Hog Producers in Alberta* (Alberta Pork and AAFRD, http://www.agric.gov.ab.ca/livestock/pork/bmp/bmp_hogs.html)
- *Beneficial Management Practices: Environmental Manual for Feedlot Producers in Alberta* (Alberta Cattle Feeders' Association and AAFRD, http://www.agric.gov.ab.ca/livestock/beef/bmp/bmp_feedlot.html)
- *Beneficial Management Practices: Environmental Manual for Dairy Producers in Alberta* (Alberta Milk and AAFRD, <http://www1.agric.gov.ab.ca/Sdepartment/deptdocs.nsf/all/epw7716?opendocument>)
- *Guidelines for Beneficial Management Practices: Environmental Manual for Poultry Producers in Alberta* (AAFRD, Alberta Chicken Producers, Alberta Egg Producers, Alberta Hatching egg Producers and Alberta Turkey Producers, <http://www1.agric.gov.ab.ca/Sdepartment/deptdocs.nsf/all/epw7717?opendocument>)

4.2.2 Mixing and Loading

When mixing and loading fertilizers, it is inevitable that a spill will occur eventually. Using proper procedures and precautions will minimize or eliminate the risk of contamination from spills.

Follow these guidelines for proper fertilizer mixing and loading:

- ✦ Clean up spills when they occur.
- ✦ For dry fertilizer, if you use a permanent mixing and loading area, the mixing pad should be impermeable. Sweep up any spilled dry fertilizer, and store it in a clean container until it can be used.
- ✦ For wet fertilizer, if you use a permanent mixing and loading area, ensure that any spills or leaks can be collected and contained. The mixing pad should have an impermeable floor, curbs and a sump.
- ✦ For mixing wet fertilizers, either have a backflow preventer on the water supply or ensure that there is a 15-cm (6-inch) air gap between the water and the hose. If possible, use a closed handling system to transfer the fertilizer directly from the storage container to the applicator equipment, so people and the environment are not exposed to the fertilizer.
- ✦ Do not leave filling equipment unattended.
- ✦ Ensure that loading takes place at least 30 m (100 ft) away from a well or surface water.
- ✦ If loading fertilizers in the field, make sure to use different sites to prevent buildup.

4.2.3 Disposal

Guidelines for disposal of fertilizer rinsate and packaging are:

- ✦ Apply fertilizer rinsate to a cropped area at a distance greater than 10 m (33 ft) from any surface water source and greater than 60 m (200 ft) from any well.
- ✦ To dispose of dry fertilizer bags, bundle the completely empty bags and dispose of them at a licensed landfill.

For more information, see the Canadian Association of Agri-Retailers' *Fertilizer Storage and Handling*.

4.3 Petroleum Products

Any fuel or lubricant can cause problems if it contaminates a water source or the soil. Under the EPEA, all gasoline and diesel fuel spills and leaks of 200 L (44 gal) or more must be reported to Alberta Environment. Spills of a lesser amount must be reported if the spill is causing, has caused or may cause an adverse effect on the environment. A leak or spill of any amount into surface water or groundwater must be reported. Cleanup costs can be applied as a penalty.

At present, the Alberta Fire Code: 1997, governs the storage and handling of petroleum products. This Code is administered by Alberta Municipal Affairs. Although on-farm storage and handling of petroleum products is exempt, the following practices serve as guidelines for Alberta farms.

Liquid petroleum products, such as gasoline, diesel fuel and kerosene, must be stored safely to prevent spills and leaks. These products can move quickly through the soil and into groundwater. A small leak of one drop per second can release about 900 L (200 gal) of gasoline into the groundwater in one year. But it takes only a few litres of gasoline to severely pollute a farmstead's drinking water. Low levels of fuel pollution in water are almost impossible to smell or taste. Water that seems pure may be contaminated and harmful to human health.

Explosions are another potential danger from petroleum products. Vapours from an underground leak can collect in basements, sump pits or other underground structures and could explode.

4.3.1 Storage

Storage Facility

- Install tanks in accordance with the Alberta Fire Code. A good option is to hire a registered contractor to do the installation.
- Locate tanks well away from water sources, buildings, ignition sources and other fuel tanks (see Table 4.1).
- For on-ground storage tanks, install secondary containment such as dikes or double-walled tanks to contain spills. If there is no secondary containment, locate tanks downslope from buildings, grain storages, water wells and surface water so any spilled or leaked fuel drains away from those.
- Mount tanks at ground level or supported on concrete or metal that can provide at least a two-hour fire-resistant rating. Use a firm foundation for tanks to prevent uneven settling.
- Protect aboveground tanks, underground storage tanks and piping against corrosion to prevent leaks.
- Protect all pumps, lines and tanks from collision damage. Install bollards (barriers constructed of a sturdy material, such as steel piping filled with cement, set up close to fuel tanks to guard against collision damage). Make sure fill-up hoses are long enough so vehicles and farm equipment can be kept at a distance from the tanks.
- Install anti-siphon valves between the pump and the tank to prevent the tank from draining if the line is broken.
- Lock all fuel tanks when not in use to reduce the risk of spills due to vandalism and theft.
- Keep the area around the tank free of vegetation and debris.
- Keep ignition sources away from fuel tanks, especially from the tank's vents that discharge fuel vapours. Ignition sources include electric motors, yard lights, power lines, air conditioning or heating units, road traffic and garbage burning barrels.
- Ground pumps and vehicles to avoid buildup of static electricity.

TABLE 4.1

SEPARATION DISTANCE GUIDELINES FOR PETROLEUM STORAGE

	MINIMUM DISTANCE FROM FUEL STORAGE	
	(m)	(ft)
Water well	90	300
Surface water body	30	100
Any building	3	10
Source of ignition*	6	20
Another fuel tank	1	3
Propane cylinder	3	10
Propane tanks	6	20

* This includes houses, garages, barns, sheds, etc. and should include the house nearest the tanks. If the tanks are located in a residential area, the minimum distance should be 30 m (100 ft).

Adapted from: Alberta Environment, *Guidelines for the Storage and Handling of Petroleum Products*, 1999.

4.3.1 Storage

Storage Facility

- ▶ Install tanks in accordance with the Alberta Fire Code. A good option is to hire a registered contractor to do the installation.
- ▶ Locate tanks well away from water sources, buildings, ignition sources and other fuel tanks (see Table 4.1).
- ▶ For on-ground storage tanks, install secondary containment such as dikes or double-walled tanks to contain spills. If there is no secondary containment, locate tanks downslope from buildings, grain storages, water wells and surface water so any spilled or leaked fuel drains away from those.
- ▶ Mount tanks at ground level or supported on concrete or metal that can provide at least a two-hour fire-resistant rating. Use a firm foundation for tanks to prevent uneven settling.
- ▶ Protect aboveground tanks, underground storage tanks and piping against corrosion to prevent leaks.
- ▶ Protect all pumps, lines and tanks from collision damage. Install bollards (barriers constructed of a sturdy material, such as steel piping filled with cement, set up close to fuel tanks to guard against collision damage). Make sure fill-up hoses are long enough so vehicles and farm equipment can be kept at a distance from the tanks.
- ▶ Install anti-siphon valves between the pump and the tank to prevent the tank from draining if the line is broken.
- ▶ Lock all fuel tanks when not in use to reduce the risk of spills due to vandalism and theft.
- ▶ Keep the area around the tank free of vegetation and debris.
- ▶ Keep ignition sources away from fuel tanks, especially from the tank's vents that discharge fuel vapours. Ignition sources include electric motors, yard lights, power lines, air conditioning or heating units, road traffic and garbage burning barrels.
- ▶ Ground pumps and vehicles to avoid buildup of static electricity.

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Any building	3	10
Source of ignition*	6	20
Another fuel tank	1	3
Propane cylinder	3	10
Propane tanks	6	20

* This includes sources such as motors and electrical sparks unless electrical sources meet the Code of Electrical Installations at Oil and Gas Facilities.

Monitoring the Facility

- ▶ Keep fuel lines, hoses, valves and nozzles in good repair.
- ▶ Inspect overhead tanks and the area around the tanks for leaks two times monthly.
- ▶ Monitor the volume of fuel in all tanks to detect leaks and other losses. Meter your use to keep track of how much fuel you are using and subtract this amount from the total amount you received.

4.3.2 Dispensing Fuel

- ▶ Ensure that the dispenser unit is ULC and CSA approved, with automatic shut-off valves.
- ▶ Use a hand pump or an electric pump. If using an electric pump, it must be installed according to the Code of Electrical Installations at Oil and Gas Facilities. Gravity feed is not acceptable for dispensing fuel.
- ▶ Close the valves on tank discharges when they are not in use to prevent leakage through the hose or nozzle.
- ▶ When filling containers such as jerry cans, make sure they are supported in an upright position so they do not fall over.

4.3.3 Spills and Leaks

Emergency Plan

Prepare an emergency plan in case of a leak or spill. This written plan should include the location of emergency equipment, emergency telephone numbers, cleanup methods and steps to follow.

If a spill or leak occurs, contact Alberta Environment (1-800-222-6514).

For an aboveground spill or leak:

- ▶ Stop the flow of fuel.
- ▶ Contain and clean up the spilled fuel.
 - For spills on floors, use absorbent materials such as sawdust or rags.
 - For spills on soil, excavate the contaminated soil.
- ▶ Shovel the contaminated soil or absorbent materials into a clean container.
- ▶ Dispose of contaminated cleanup materials and soil in accordance with Alberta Environment guidelines.

For a leak or spill in an underground tank or line, contact Alberta Environment for the procedures to follow.

4.3.4 Disposal

Used oil is the largest single source of hazardous recyclable material in Alberta. If improperly managed, used oil and its components such as (heavy metals, chlorinated solvents and PCBs) can contaminate air, soil and water.

For proper disposal:

- ▶ Collect all used oil, oil filters and oil containers. They can be returned at no charge to the nearest recycling centre. For locations, contact the Alberta Used Oil Management Association (AUOMA) 1-888-922-2298 or online at <http://www.usedoilrecycling.com/html/alberta.cfm>.
- ▶ Most bulk fuel agents will take solvents, cleaning fluids and glycols (antifreeze).
- ▶ Waste oil companies will pick up waste oils on the farm, if the farm has about 1000 L of product per visit. These companies are in the yellow pages under Oil-Waste.
- ▶ Hazardous waste depots will also accept used materials contaminated with petroleum products.

4.4 Treated Seed

Practices to properly store and dispose of treated seed include the following:

- ▶ If you are treating bulk seed on the farm, treat only as much as you need for immediate use.
- ▶ For temporary storage on the farm, place the seed in a secure, sealed container.
- ▶ If you purchased treated seed and have leftover seed in unopened bags, return the bags to the dealer.
- ▶ If you have leftover treated seed that cannot be returned to a dealer, plant the seed at a rate not exceeding three times the normal seeding rate, or contact a regional sanitary landfill for authorization to bring the seed to the landfill for immediate burial.

4.5 Information Sources

4.5.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- ▶ Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- ▶ Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada; website: www.agr.gc.ca/pfra
- ▶ Alberta Environment: General: 780-422-4505; Action-on-Waste Recycle Information: 1-800-463-6326; Environmental Response Centre: 1-800-222-6514; website: <http://www3.gov.ab.ca/env/>
- ▶ Alberta Used Oil Management Association: recycling centre locations: 1-800-922-2298; website: <http://www.usedoilrecycling.com/html/Alberta.cfm>

4.5.2 References

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CHAPTER

5.0

Post-Harvest Crop Storage

This chapter describes beneficial management practices to properly store grain, hay and silage to protect the environment and to maintain crop quality.

Grain, hay and silage need to be properly stored to protect the environment and to maintain crop quality. Leak-proof covers are essential for grain and silage and are preferred for hay. Storage should not be in a location where water runs or ponds. Storage structures need to be secure and stable. It is advisable to consult an engineer on the location, design and construction of large storage structures.

For information on the design of crop storage facilities, go to the Canada Plan Service publications on Grain, Forage and Feed Structures (<http://www.cps.gov.on.ca/english/gs7000/grain.htm>).

5.1 Grain and Hay Storage

5.1.1 Grain Storage

- ✦ Use water-proof and rodent-proof storage to prevent rotting and/or fecal contamination of the grain. Check the storage area regularly for holes or cracks and seal them.
- ✦ After use, clean out the leftover material from bins, and bury the material or take it to a landfill. Check for signs of insects and rodents in the bins.

For more information, see *Management of Cereal Grain in Storage* (AAFRD) and *Storage of Canola* (AAFRD).

5.1.2 Hay Storage

- ✦ Cover bales with tarps to reduce spoilage, nutrient leaching and dry matter losses.
- ✦ Store bales on well drained areas.
- ✦ To protect hay stored outdoors from deer and elk, use electric fencing or provide alternative food sources for the animals (see box).
- ✦ To reduce fire hazard, store hay away from buildings, shelterbelts and power lines.



⇒ Cover bales, with tarps to reduce spoilage, nutrient leaching and dry matter losses.

Courtesy of AgTech Centre - AAFRD

Minimizing Damage by Deer and Elk to Stored Feed

- ▶ Stack and wrap round bales at least two tiers high and keep edges as straight as possible to prevent deer and elk from climbing the stacks.
- ▶ Use appropriate fencing to protect stored feed from deer and elk.
- ▶ Clean up spilled grain, loose hay and other feed.
- ▶ Do not allow wildlife to linger and lose their fear of humans because they will attract others.
- ▶ Keep wildlife away from yards. Scarecrows wearing clothes with human scent and radios may be enough to keep them away if they have not become conditioned to humans or dependent on the food source.
- ▶ Contact your local Alberta Fish and Wildlife office for information on stack protection, scaring devices, repellents, fencing and other prevention programs.

Source: North American Waterfowl Management Plan, Alberta Prairie Care, 2001, *Wildlife Damage Compensation and Prevention*, Publication No. NWMP_007.

For more information, see *Using Electric Fences to Protect Stored Hay from Elk and Deer* (AAFRD) and *Wildlife Damage Compensation and Prevention* from the North American Waterfowl Management Plan.

5.2 Silaging

Silaging produces a palatable, nutritional feed supply. Silage can be harvested in almost all weather conditions. It offers a way to salvage hail-damaged, frozen and weedy crops, and can also be used as an environmentally friendly form of weed control. Fields intended for silage can be planted to a variety of crops, increasing the diversity of plant life.

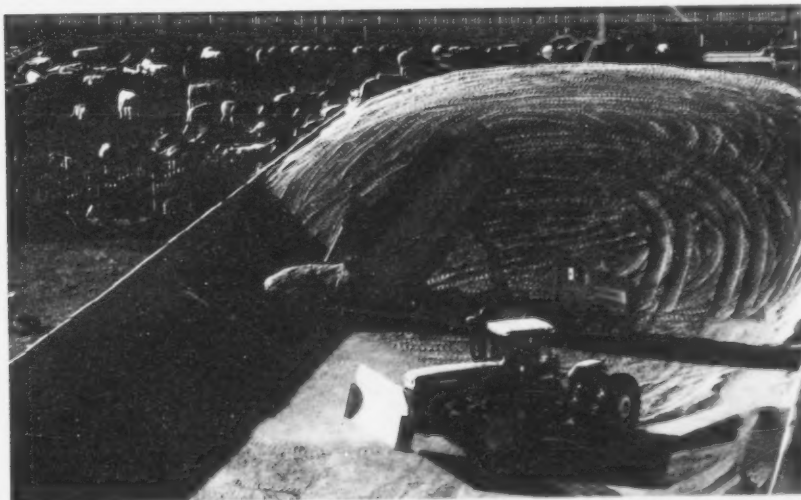
5.2.1 Silage Seepage

Silage must be handled and stored properly to prevent seepage. Silage seepage contains high concentrations of nutrients and acid that can increase the levels of ammonia, nitrate and iron in the water. Seepage can enter water bodies by runoff or percolation through the soil.

When selecting a storage location, investigate soil, topography and water table status to determine the environmental risk to nearby water. The storage facility should be well away from watercourses and flood plains, and more than 100 m (330 ft) from a water source. It should also be placed where the natural drainage is away from nearest surface water body.

Make sure all parts of your storage, including the lining, are in good condition. Concrete floors and walls should have no cracks. Silage covers can be designed to remove rainfall away from silage so water cannot seep into or under the silage.

Silage moisture should be lower than 65% to minimize seepage. Prevent any seepage from reaching water sources. It is best to have a professionally designed and well-maintained seepage collection system. Prepare a plan to deal with the collected seepage on an annual basis; the seepage can be applied to your crop land.



⇒ Silaging produces a palatable, nutritional feed supply.

Courtesy of AAFRD, AgTech Centre - AAFRD

5.2.2 Silage Gases and Odours

Silaging produces greenhouse gases – carbon dioxide and sometimes oxides of nitrogen. Silage odour may be offensive to some people. Locate silaging facilities downwind from nearby residences.

For more information on silage storage, see *Storage of High Moisture Barley* (AAFRD), *Silage Manual* (AAFRD), and *Alberta Forage Manual* (AAFRD).

5.3 Information Sources

5.3.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- ▶ Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- ▶ Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada; PFRA website: www.agr.gc.ca/pfra
- ▶ Alberta Environment: phone: 1-780-944-0313; website: <http://www3.gov.ab.ca/env/>

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CHAPTER 6.0

Energy Inputs

This chapter outlines beneficial management practices to decrease fuel consumption and discusses alternative energy sources.

6.1 Energy Efficiency

By decreasing the amount of fuel used, you can lower your energy costs, boost the efficiency of your operation and decrease the amount of harmful emissions released into the environment. Energy accounting provides a simple process to determine your energy use and costs to help you identify which energy-saving options will work best for your operation.

For more information on energy efficiency, see *First Steps to Energy Management: Save Energy and Money* (AAFRD). This guide will help you through the steps to add up your energy use and costs and provides some simple, low-cost ideas for reducing energy use on your farm. For a copy, call the AgTech Centre (1-403-329-1212) or the Conservation and Development Branch ((1-780-422-4385). All Alberta Government offices may be reached toll-free by first dialing 310-0000.

Practices to reduce fuel consumption include:

- ▶ Keep cutting tools sharp and implements level to the ground to prevent unnecessary power requirements.
- ▶ Practice routine and timely maintenance on all farm equipment and implements.
- ▶ Perform multiple tasks on each pass through the field where possible.
- ▶ Inflate tires according to the manufacturer's recommendations.
- ▶ Use radial tires
- ▶ Reduce tillage.
- ▶ Match the tractor to the load. The typical optimum pull is 40% of the tractor weight.
- ▶ Add or remove ballast to match the load when tractors are used for different field operations. Removing weight also reduces soil compaction.
- ▶ Gear up and throttle down: Shift to a faster gear and slow the engine speed to maintain the desired field speed. This decreases the fuel consumption, but when the engine speed is reduced, reaction time of the tractor hydraulics will be slower and PTO speed is correspondingly reduced. This could result in unacceptable performance and/or reduced productivity from the PTO-driven device. Gearing up and throttling down can be used when loads require less than 65% of a tractor's power.
- ▶ Shut engines off when not in use.
- ▶ For high temperature grain drying, use a continuous flow dryer.
- ▶ For low temperature aeration grain drying, use automatic controls. If you do not have automatic controls, monitor the drying process regularly.

For more information, see the *AgTech Centre Innovator* newsletter, Volume 1, Issue 2 ([http://www1.agric.gov.ab.ca/\\$department/newslett.nsf/all/agin39?opendocument](http://www1.agric.gov.ab.ca/$department/newslett.nsf/all/agin39?opendocument)).

6.2 Alternative Energy Sources

Wind power, solar power and biodiesel are the three most common renewable energy sources for agricultural users at present. Other alternatives such as biogas and earth energy are being developed and may be good options in the future. These options reduce the use of non-renewable energy sources, and so help to reduce harmful emissions.

6.2.1 Wind Power

Modern wind turbines can provide reliable, cost-effective, pollution-free energy for individuals and communities. The cost of these systems depends on the power output. A 1-kW system costs about \$5,000, and a large-scale commercial system that produces 600 kW can cost \$1 million.



→ Wind turbines can provide energy for individuals and communities.

Courtesy of AAFRD

Wind systems need a relatively consistent wind flow. Trees and other obstructions can impede wind flow to the rotors. Collect at least one year of wind data before selecting a site. A wind power system usually requires an average annual wind speed of at least 15 km/h. An average wind speed of greater than 25 km/h is desirable, and over 29 km/h is excellent, especially if the intent is to sell the power.

6.2.2 Solar Power

Capturing enough solar energy for effective use depends on available solar energy, weather conditions, location, the technology used and the application. Although the initial cost of solar energy technology can be high, it has the potential to reduce energy bills considerably and provide an economic source of power in remote areas.



➡ Solar energy can be used to convert sunlight into electrical power.

Courtesy of AAFRD

On farms, solar energy can be used for heating or to convert sunlight into electricity to power such things as water pumps, electric fencing and grain dryers.

6.2.3 Biodiesel

Biodiesel is made from renewable resources, such as soybean oil, canola oil or animal fats. This high-performing fuel improves air quality by greatly reducing emissions of carbon monoxide, ozone-forming hydrocarbons, hazardous diesel particulates, acid-rain-causing sulphur dioxide, and carbon dioxide. However, nitrogen oxide emissions may increase.

Biodiesel-powered engines deliver similar torque, horsepower, haulage rates and kilometres per litre as petroleum-powered diesels. Biodiesel can be used in existing engines and fuel injection equipment without harming performance. It has superior lubricating properties and can extend engine life. Winter operating procedures are the same for biodiesel as they are for number two petroleum diesel. Biodiesel can be blended with petroleum diesel or used neat (100%). Some farm equipment manufacturers have approved the use of soy-based biodiesel fuel blends for some of their diesel-powered engines.

Biodiesel is currently not available for retail sale, so producers must find their own source. Although it is possible to produce biodiesel on farm, it is not currently an economic option in most situations. Commercial biodiesel is widely available in Europe and may be available in Canada later in this decade.

For more information on these and other alternative energy sources, see recent issues of the AgTech Centre Innovator newsletter or go to AAFRD's website, click on 'Engineering' and follow the links.

6.3 Information Sources

6.3.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- ▶ Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- ▶ Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada, or the PFRA website: www.agr.gc.ca/pfra
- ▶ Alberta Environment: phone: 1-780-944-0313; website: <http://www3.gov.ab.ca/env/>
- ▶ Natural Resources Canada, Office of Energy Efficiency: website: <http://oee.nrcan.gc.ca/english/>

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CHAPTER 7.0

Wildlife Habitat

Natural ecosystems are a vital component in sustaining ecological functions. This chapter describes beneficial management practices for enhancing three main types of farm habitat: cropped land, non-cropped land, and wetland and riparian areas.

Natural ecosystems are a vital component in sustaining ecological functions. They are essential for a healthy environment for plants, animals, and humans, as well as for human activities like agriculture (see Section 2.8). Conserving diverse ecosystems is the responsibility of everyone, including those in agriculture.

Food, water and cover are the three essential components of wildlife habitat. To retain and restore habitat, begin by taking stock of your farm. Consider the natural soil conditions and vegetation communities on the land before it was converted to agricultural use. Assess the different habitat types and consider what options would work best given your finances, management style and long-term goals. The options can be simple, like retaining existing treed areas or adding fall-seeded cereals to your crop rotation, or more involved, like planting natural areas to link existing habitat areas so animals can travel safely between these areas.

The following sections provide options for enhancing three main types of farm habitat: cropped land; non-cropped land; and wetland and riparian land.



⇒ Natural ecosystems are important in sustaining ecological functions.

Courtesy of DUC

7.1 Cropped Land

Cropped lands can provide cover and food for ground-nesting birds and many small mammals. Practices that improve habitat also benefit soil, water and air quality.

BMPs to improve habitat on cropped land include:

- ✦ Convert lands that are marginally productive for annual crops into long-term forage production. This provides habitat for ground-nesting birds and small mammals.

- » Add perennial or annual forages to your crop rotation to provide habitat for ground-nesting birds and small mammals. Manage perennial forage stands for longer life.
- » When haying, use a flushing bar to flush out wildlife (see box).
- » Delay haying near wetlands to reduce nesting losses for ground-nesting birds. Wait until at least July 1, and, whenever possible, delay until about mid-July, when nesting is usually near completion.
- » Plant fall-seeded crops to improve habitat for ground-nesting birds.
- » Reduce or eliminate tillage to minimize damage to nests and to increase the diversity of life in the soil (e.g. earthworms and mycorrhiza).
- » Eliminate fall tillage to provide some cover and food during the winter.
- » Rather than using conventional fallow, use strip cropping to provide some habitat.
- » Use integrated pest management to minimize harm to non-target species.

Wildlife Flushing Bar

A flushing bar is an aluminum bar attached to the front of a tractor during haying operations. As the tractor moves along, chains or belts hanging down from the bar drag through the hay. The motion and noise scare ducks, songbirds, fawns and other wildlife out of the way of the equipment, saving their lives.



⇒ Flushing bar mounted on a tractor.

Courtesy of DUC

For more information, contact your nearest Ducks Unlimited Canada office.

7.2 Non-cropped Land

Non-cropped land includes land used for native hay, pasture, shelterbelts, woodlots, bush, abandoned farmsteads and field borders. This land often has patches of native plants needed for wildlife habitat.

BMPs to improve habitat on non-cropped land include:

- ▶ Retain existing natural areas to provide habitat for birds, small mammals, and insects.
- ▶ Enhance the habitat value of treed areas, including shelterbelts, by such practices as adding fruit- and nut-producing trees and shrubs and leaving dead trees, to provide habitat for birds, small mammals, insects and fungi.
- ▶ Provide or retain corridors between key habitat areas to provide shelter for wildlife moving between these areas. Fencelines and shelterbelts can be used as corridors.
- ▶ For hay land, use a flushing bar during haying. Delay haying near wet areas to minimize nesting losses for ground-nesting birds; wait until at least July 1, and, whenever possible, delay until about mid-July, when nesting is usually near completion.
- ▶ For pasture land, avoid overgrazing, and delay spring grazing near wet areas to minimize damage to nests.
- ▶ Enhance the habitat value of idle areas like field borders and abandoned farmyards by such practices as planting a variety of grasses, legumes or shrubs, and adding nesting boxes.
- ▶ Maintain the edges between habitat types because these areas usually have more diverse food and cover.



→ Fencelines can be used as travel corridors.

Courtesy of Agriculture and Agri-Food Canada - PFRA



➡ Spruce trees provide high quality winter cover.

Courtesy of Agriculture and Agri-Food Canada – PFRA



➡ Northern saw-whet owls often nest in standing dead trees with old woodpecker cavities.

Courtesy of Agriculture and Agri-Food Canada – PFRA

7.3 Wetland and Riparian Land

Wetlands are lands covered by water for all or part of the year. They are wet long enough to influence soil characteristics and to support water-loving plants. Healthy wetlands and riparian areas are important in reducing flooding, preventing erosion, protecting water quality and providing habitat.

BMPs to improve habitat in wetland and riparian areas include:

- ✦ Retain temporary wetlands. Small spring ponds provide important early spring breeding habitat for wildlife.
- ✦ Grow perennial forages for hay in wet areas to provide habitat for birds, small mammals, amphibians and insects, and hiding cover for fawns.
- ✦ Avoid cultivating near the edges of wetlands.
- ✦ Maintain, restore or enhance riparian vegetation to provide: breeding, feeding, nesting sites, travel corridors, food and cover for many bird species; critical habitat for deer, moose, elk and pronghorn antelope; shade and temperature regulation for improved fish habitat.
- ✦ Delay mowing and haying of grassed waterways and other wet areas until mid-July to reduce nesting losses and fawn mortality. Use a flushing bar when haying.



⇒ Winter wheat provides benefits to nesting water fowl and other ground nesting birds.

Courtesy of DUC



→ Habitat and wildlife are inseparable.

Courtesy of DUC

7.4 Information Sources

7.4.1 Contacts

- ▶ Ducks Unlimited Canada, phone: 1-780-489-2002; website: <http://www.ducks.ca/index.html>
- ▶ Cows and Fish Program (the Alberta Riparian Habitat Management Program), phone: 1-403-381-5538; website: <http://www.cowsandfish.org/index.html>
- ▶ Partners in Habitat Development, 1-403-362-1414
- ▶ Alberta Fish and Game Association, phone: 1-780-437-2342; website: <http://www.afga.org/Start/startfg.htm>
- ▶ Your district office of Agriculture and Agri-Food Canada – PFRA, or the PFRA website: www.agr.gc.ca/pfra
- ▶ Alberta conservation Association (ACA), phone toll free: 1-877-969-9091; email: info@ab-conservation; website: www.ab-conservation.com
- ▶ Nature Conservancy of Canada (NCC), phone toll free: 1-877-262-1253; email: Alberta@natureconservancy.ca; website: www.natureconservancy.com

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CHAPTER 8.0

Community Relations

This chapter discusses community considerations in crop production, outlines ways to prevent and resolve conflict, and describes some beneficial management practices to help avoid some of the common causes of conflicts for cropping operations.

In recent years, the number and intensity of conflicts involving farmers has increased. Debates have arisen over environmental, political, economic and social issues. Many of the debates have concerned livestock operations, but conflicts related to cropping operations can also occur.



→ Good communication helps prevent conflicts.

Courtesy of AAFRD

A 1998 survey of Canadian farm organizations and producers identified conflict over farm practices as one of the leading threats to the agricultural industry's future competitiveness. Neighbours of farming operations are concerned about issues like odours from manure spreading, noise and dust storms that can harm their quality of life as well as environmental concerns like the risk of contamination of surface water (such as rivers, streams, lakes and wetlands) and groundwater.

This chapter outlines ways to prevent and resolve conflict, and describes some BMPs to help avoid some of the common causes of conflicts for cropping operations.

8.1 Preventing, Managing and Resolving Conflict

Conflict is a struggle between two or more people because of a real or perceived difference in needs or values. Properly managed, conflict can be productive because it can:

- ▶ encourage people to examine issues more carefully.
- ▶ deepen our understanding of problems.
- ▶ open the door to new ideas and alternative solutions.
- ▶ help foresee the consequences of proposed actions.
- ▶ enable people to take risks and solve problems.

Learning the skills necessary to prevent, manage and resolve conflict is important in today's society. The following tips and strategies to help producers prevent, manage and resolve conflict are based on focus groups involving producers and government representatives held by the Canadian Farm Business Management Council (CFBMC).

For more information on conflict management, see *Farming with Neighbours, A Guide for Canadian Farmers on Preventing and Resolving Community Conflicts over Farming Practices*, from the Canadian Farm Business Management Council (phone: 1-800-232-3262).

8.1.1 Preventing Conflict

The most important thing producers can do to reduce the risk of conflict is to ensure communication with neighbours is open, honest and thorough. This kind of communication improves mutual understanding and increases the possibility of solving problems in a way that meets the needs of both the producer and the neighbours.

Participants in the CFBMC's focus groups suggested that compliance with the laws governing farm management practices should be regarded as the bare minimum. Using 'progressive' farm management practices, including the BMPs covered in this manual, will help prevent conflicts.



⇒ Becoming more involved in your community can help to reduce conflicts.

Courtesy of AAFRD.

Be a Good Neighbour

Being a good neighbour helps to build “social capital” that can be drawn upon like a bank account when problems arise.

Practices to strengthen your relationship with your neighbours include:

- ▶ getting to know the neighbours and letting them get to know your operation.
- ▶ being friendly.
- ▶ being helpful to neighbours in need.
- ▶ getting involved in the community.
- ▶ supporting local businesses and hiring local youths.
- ▶ supporting and making donations to local charities and community groups such as sports teams and youth groups.
- ▶ hosting a farm tour, picnic/barbecue or potluck to generate goodwill and provide an opportunity for neighbours to ask questions about your operation in a relaxed atmosphere (see box).



➡ Farm tours are one way to let your neighbours know about your operation.

Courtesy of AAFRD

Tips for Tours and Open Houses

- ▶ Find out who's coming, why, and what they want to see.
- ▶ Decide in advance and tell guests whether photos are allowed.
- ▶ Do a dry run. Walk all around the farm, ideally with a non-farm friend to get input on the way guests will see it.
- ▶ Ensure there are no hazards to public safety on the tour and that the farm is clean and tidy and livestock are healthy. Avoid waste disposal areas, sick animals, and storage areas for medications and agri-chemicals.
- ▶ Anticipate questions guests are likely to ask, including questions on challenging issues, such as food safety, genetically modified foods, chemicals and residues, air, water quality, and soil pollution. Have clear, factual, well-reasoned answers ready for these questions.
- ▶ Prepare some written information about your farm to have as a hand-out at the open house or to use when you invite people to visit.
- ▶ Practice answering questions with family members or colleagues. Video the practice session. Appear confident; otherwise people may think you are avoiding questions or concealing the truth.
- ▶ If you don't know the answer to a question, say so. Then offer to find out. Do not be baited into saying something that you may regret later.
- ▶ Draw attention to farming practices that address society's concerns as well as the agri-food industry's contribution to the economy and community fabric.
- ▶ Tailor each tour/presentation to the audience.
- ▶ Have technical experts available to answer questions and enhance confidence in your operation.
- ▶ Provide washrooms.
- ▶ Smile. Have fun. Guests should leave with good feelings about the tour.

Evaluate Your Operation

Make sure you are following the regulations and standards that govern your operation, and also look for practical ways to go beyond these minimum requirements. The Alberta Environmental Farm Plan program is one way for you to evaluate your current operation and begin assessing options for areas where you would like to make improvements.

For more information about Alberta's Environmental Farm Plan program, call phone toll-free: 1-866-844-AEFP (2337); or visit the program's website at www.albertaefp.com.

Develop Contacts and Skills

Identify people who support your operation and keep them informed about it. You can enlist their help if concerns arise.

Working with staff from municipal and provincial governments can help you to learn about alternative practices that might suit your farm, and it can help them to learn about you and your operation.

Consider taking some courses to improve your skills in communication and dealing with people. For example, a conflict management course could help you deal more effectively with any concerns that arise, or a course on communicating with the news media could help you to bring forward your views.

8.1.2 Managing Conflict

Sometimes conflict is unavoidable, no matter how much effort has been made to resolve an issue. When conflict does erupt, manage it to minimize the damage.

Canadian farmers who participated in the CFBMC focus groups had the following tips to help prevent a conflict from escalating:

- ▶ Take the matter seriously. Don't try to deny there's a problem.
- ▶ Stay calm. Don't get angry or defensive. Don't blame, accuse, chide or belittle other people; it could escalate the conflict.
- ▶ Think before acting or speaking. "Sleep on it." Be diplomatic.
- ▶ Don't let small, specific conflicts mushroom into big, broad conflicts. Ask lots of questions. Find out what the other person is upset about. Don't debate their issues.
- ▶ Search out and identify the real issues. What people say may be quite different from what they're really concerned about. Often people's concerns are rooted in fear of change or the unknown or a lack of understanding, or fear of losing control or the ability to influence decisions that will affect them.
- ▶ Deal with emotions first. Then deal with the subject of the conflict.
- ▶ Listen to and validate concerns. Acknowledge understanding of the concerns and offer to look into the matter.
- ▶ Be prompt when getting back to complainants.
- ▶ Stay on top of ongoing problems. Keep people informed of changes on the farm and progress being made.
- ▶ Do whatever is practical to fix problems and mitigate damage.
- ▶ Always tell the truth.
- ▶ Admit to mistakes. Make amends if possible. Take responsibility for employees' actions.
- ▶ When others make mistakes, help them save face.
- ▶ Shift the emphasis to mutually acceptable solutions.

For more information, see the Canadian Farm Business Management Council's *Preventing, Managing and Resolving Conflicts on Canadian Farms*.

8.1.3 Resolving Conflict

Good communication is essential for resolving conflicts. Listen and understand first before explaining your own intentions. Focus on understanding the meaning of your neighbours' message from their perspective as communicated by their words and behaviour.

The consequences of failing to resolve conflicts may include:

- ▶ bad publicity, loss of credibility, and loss of goodwill
- ▶ fines and penalties

- ▶ lawsuits and appeals
- ▶ referendums and petitions
- ▶ more regulations for the whole industry
- ▶ increased probability of future conflicts

Role of the Farmers' Advocate

If you are unable to resolve your conflict, you may be able to turn to the Office of the Farmers' Advocate of Alberta. Under the amended *Agricultural Operation Practices Act* (AOPA), the Farmers' Advocate now has a formal process for mediating complaints about non-regulatory concerns like noise, smoke and odours from agricultural operations.

Where a complaint concerns an agricultural operation that is meeting the regulations, the Farmers' Advocate will provide the operator and the complainant with a way to resolve their disagreement outside of the courts. The resolution process can help to identify practical ways the farmer can address neighbours' concerns. The process can also help complainants to better understand what is involved in acceptable agricultural practices; this can be especially important for people who are new to living in rural areas.

If this mediation process is unsuccessful, then the Farmers' Advocate can set up an Agricultural Practices Review Committee, made up of industry peers, to determine whether the operation is following generally accepted practices. The peer review committee is composed of people operating in the same sector as the operation the complaint is levelled at. The committee conducts a detailed study of the operation and develops some directions or suggestions.

If the dispute remains unresolved, then a report is written which can be used by the court system.

8.2 Reducing Nuisances for Neighbours

Issues for neighbours of crop operations include environmental concerns (see Section 2.0) and nuisances like noises, dust and odours. Noises, dust and odours can seriously harm the quality of life for neighbours and may have other impacts. Communication with your neighbours, planning of your farm activities to reduce nuisances, and commonsense consideration of others can often reduce or prevent these problems.

8.2.1 Noise

Noise concerns for neighbours often relate to the volume of the sounds and/or the timing. Try to prevent noise problems before they develop. Noise problems left unresolved can cause bad relations between you and your neighbours.

BMPs to prevent or reduce noise problems:

- ▶ Keep a noise source and the neighbours an adequate distance apart.
- ▶ Properly maintain machinery.
- ▶ Restrict noisy activities to regular daytime hours, whenever possible. Confine night-time activity to those areas most remote from neighbours.
- ▶ When possible, avoid noisy practices during weekends, especially long weekends.
- ▶ Ensure that mufflers are functioning as designed, and avoid leaving equipment idling for prolonged periods near neighbouring homes.
- ▶ Where possible, avoid night operation of irrigation pumps located near neighbours.

- ✦ If equipment is to be used as a stationary power source, erect a noise barrier.
- ✦ The fan/burner unit of a grain dryer can be noisy. Locate fans on the side of the building facing away from neighbours and direct the fan intake axis away from neighbours. Older dryers can be refitted with newer, quieter fans. Use fans with low decibel ratings or fans with adjustable pitch blades that provide some control of noise level.

8.2.2 Dust

Dust concerns from crop operations can arise from blowing soil and from farm-related traffic. Blowing soil can cause respiratory problems with people and animals. Blowing soil may also contain seeds, pollen and plant tissue, as well as agrochemicals, including pesticides. These materials can cause health problems and, in the case of pesticides, contaminate **non-target** areas. Blowing soil can also reduce visibility on roads and highways and result in serious traffic accidents. As well, clearing roads and ditches of blown soil from dust storms can be expensive for municipalities. Dust from farm traffic can be a concern during peak agricultural activity, such as harvesting or manure hauling.

BMPs to reduce dust problems:

- ✦ Use practices to prevent wind erosion such as reducing or eliminating tillage (see Section 3.3).
- ✦ When possible, reduce farm-related traffic immediately before and on weekends, especially long weekends.
- ✦ Wet down the road in front of neighbours' yards and slow down your travel speed near their yards.
- ✦ Drive with your lights on so others can see your vehicle more easily.



➡ During periods of heavy farm-related traffic, wet down dusty roads near neighbouring residences.

Courtesy of AAFC/REI

8.2.3 Odour

Frequent strong odours can be very unpleasant for neighbours, disrupting their routines and reducing the pleasure they take from being on their property. The most common odour concerns for neighbours of cropping operations are from manure and silage operations.

BMPs to reduce odour concerns for your neighbours:

- ▶ Let neighbours know in advance when manure spreading or other odour-producing activities are planned.
- ▶ If neighbours have special events planned, try to work around them.
- ▶ When possible, avoid practices that cause odour on or immediately before weekends, especially long weekends.
- ▶ Spread manure on cool days with some air movement for better odour dispersion.
- ▶ Spread manure when the wind is blowing away from neighbours.
- ▶ Incorporate manure within 12 hours, or inject manure.
- ▶ Locate silaging facilities downwind from nearby residences.
- ▶ Use composted manure in odour-sensitive areas.



⇒ Manure injection reduces odours.

Courtesy of Tri-Precision Industries

8.2.4 Traffic Volumes

At busy times of year, farm traffic volumes can be high and may be a nuisance for neighbours.

BMPs to prevent or reduce traffic volume concerns:

- ▶ Inform neighbours when traffic volumes are going to increase, and let them know how long the heavy traffic is expected to continue.
- ▶ Post signs in the area to let drivers know that heavy traffic can be expected.
- ▶ As much as possible, avoid heavy traffic late at night and early in the morning.
- ▶ Slow down when driving near residences.
- ▶ Don't overload trucks. Properly cover the load to reduce the risk of material being spilled or blown off from the load. If a spill occurs, clean it up as soon as possible.
- ▶ Adhere to community traffic bylaws. Reduce speed to take road conditions into account. Avoid travelling in very wet conditions.

8.3 Information Sources

8.3.1 Contacts

- ▶ Office of the Farmers' Advocate, phone: 1-780-427-2433 (dial 310-0000 first for a toll-free line); website: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/ofa2621?opendocument](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ofa2621?opendocument)
- ▶ Canadian Farm Business Management Council: phone: 1-800-232-3262, fax: 1-800-270-8301, e-mail: council@cfbmc.com
- ▶ Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>

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PROVINCE OF ALBERTA

BENEFICIAL MANAGEMENT PRACTICES
Environmental Manual for Crop Producers in Alberta

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Province of Alberta

WEED CONTROL ACT

Statutes of Alberta 1980, Chapter W-6
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and

AMENDMENT TO THE WEED CONTROL ACT

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CHAPTER 9.0

Legislation

This chapter discusses legal considerations in crop production and provides an overview of the legislation and acts that are most relevant to crop production.

A number of Alberta and federal government acts relate to the potential environmental impacts of agricultural practices. This chapter provides an overview of the acts that are most relevant to crop production. Refer to the specific acts and regulations for detailed information. If your farm includes livestock, refer to the livestock manuals in the *Beneficial Management Practices* series for the acts relating to those operations.

Striving for Excellence

The provincial and federal acts provide a foundation to ensure that agriculture is operating in a sound and responsible manner. Your operation must meet the legal requirements described in the acts and regulations. This manual is aimed at producers who are striving for excellence in environmental stewardship. Therefore, many of the practices described in Chapters 3 to 7 go beyond the basic legal requirements to help you reach your goals for an environmentally and economically successful operation.

Legal Requirements

The information in this chapter is provided for general information only. It is not intended as legal advice. Refer to the acts and regulations and consult a lawyer for legal advice on your specific legal rights and requirements.

More information on the environmental requirements under these acts can be obtained from Alberta's Natural Resources Conservation Board (NRCB), Alberta Agriculture, Food and Rural Development, Alberta Environment, Environment Canada, consultants and lawyers.

Copies of Alberta's acts and regulations are available online or through the mail from the Queen's Printer (phone: 1-780-427-4952 (dial 310-0000 for a toll-free call); website: <http://www.qp.gov.ab.ca>).

9.1 Alberta Legislation

9.1.1 Agricultural Operation Practices Act

A major component of Alberta's *Agricultural Operation Practices Act* (AOPA) is a set of environmental standards for nutrient management practices. All agricultural operations must comply by the end of 2004 with the legislation's manure management requirements to prevent water contamination and protect the soil.

Manure Application

Manure can be applied only to arable land. Surface-applied manure must be incorporated into the soil within 48 hours, unless it is applied to forage or direct seeded crops. When applying manure, producers need to take into account setback distances from water bodies, slope, soil type, and the amount of nitrate and salt in the soil.



⇒ Surface-applied manure must be incorporated into the soil within 48 hours.

Courtesy of AAFCO

Setback Requirements for Injected and Incorporated Manure

When applying manure, the following setback distances from common bodies of water must be met (from AOPA Standards and Administration Regulation, Section 24):

- ✦ If the operator is directly injecting manure into the soil, injection must not occur within 10 m of a common body of water.
- ✦ If the operator is applying the manure to the soil surface and incorporating it within 48 hours, manure must not be applied within 30 m of a common body of water.
- ✦ An operator must not apply manure within 30 m of a water well.

Common Bodies of Water

Under AOPA, common bodies of water include: the bed and shore of an irrigation canal, drainage canal, reservoir, river, stream, creek, lake, marsh, slough or other exposed body of water. (See AOPA Standards and Administration Regulation Section 1 for exceptions.)

Setback Requirements for Surface-Applied Manure that is Not Incorporated

Operators who surface-apply manure on forage, direct seeded crops, and frozen and/or snow-covered soils must meet more stringent setback requirements, shown in Table 9.1. If it is possible that contamination may occur, the operator should increase the setback distance.

TABLE 9.1

MINIMUM SETBACK DISTANCES FOR SURFACE-APPLIED MANURE ON FORAGE, DIRECT SEEDED CROPS, AND FROZEN AND/OR SNOW-COVERED SOIL*

AVERAGE SLOPE**	REQUIRED SETBACK DISTANCES FROM COMMON BODY OF WATER
Less than 4%	30 m
Greater than 4% but less than 6%	60 m
Greater than 6% but less than 12%	90 m
More than 12%	No application allowed

* AOPA Standards and Administration Regulation, Schedule 2, Table 2.

** Mean expressed as a percentage calculated on the horizontal axis.

Source: Alberta Agriculture, Food and Rural Development, 2002. Information Guide: Agricultural Operations Practices Act Alberta Agriculture, Food and Rural Development.

Salt and Nitrate Loading Limitations

During growth of salt-tolerant crops, the following conditions must be met:

- soil salinity is more than 4 deciSiemens per metre (dS/m) as measured by electrical conductivity using saturated paste extract analysis, based on a representative soil sample from the top 15 cm of soil. (AOPA Standards and Administration Regulation, Section 25)
- soil salinity will increase after manure is applied by more than 1 dS/m (same analysis method). (AOPA Standards and Administration Regulation, Section 25)
- soil nitrate-nitrogen levels in the top 60 cm will increase after manure is applied to a level that equals or exceeds the limits shown in Table 9.2.

Manure applied to salt-tolerant crops must be applied to the following limits:

TABLE 9.2

NITRATE-NITROGEN LIMITS FOR MANURE-APPLIED LANDS IN ALBERTA*

SOIL	SANDY SOILS (> 45% SAND AND WATER TABLE SHALLOWER THAN 4 M)	SANDY SOILS (> 45% SAND AND WATER TABLE DEEPER THAN 4 M)	MEDIUM- AND FINE- TEXTURED SOILS
Brown	80 kg/ha (75 lb/ac)	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)
Dark Brown	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)
Black	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)	225 kg/ha (200 lb/ac)
Gray Wooded	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)
Irrigated	180 kg/ha (160 lb/ac)	225 kg/ha (200 lb/ac)	270 kg/ha (240 lb/ac)

* AOPA Standards and Administration Regulation, Schedule 2, Table 2.

Source: Alberta Agriculture, Food and Rural Development, 2002. Information Guide: Agricultural Operations Practices Act Alberta Agriculture, Food and Rural Development.

TABLE 9.1

MINIMUM SETBACK DISTANCES FOR SURFACE-APPLIED MANURE ON FORAGE, DIRECT SEEDED CROPS, AND FROZEN AND/OR SNOW-COVERED SOIL*

AVERAGE SLOPE**	REQUIRED SETBACK DISTANCES FROM COMMON BODY OF WATER
Less than 4%	30 m
Greater than 4% but less than 6%	60 m
Greater than 6% but less than 12%	90 m
More than 12%	No application allowed

* AOPA Standards and Administration Regulation, Schedule 3, Tables 1 and 2

** Slope, expressed as a per cent is calculated as the (rise/run) x 100.

Source: Alberta Agriculture, Food and Rural Development: 2002. Reference Guide: Agricultural Operation Practices Act. Alberta Agriculture, Food and Rural Development.

Salt and Nitrate Loading Limitations

Unless you have an NRCB-approved nutrient management plan, you must not apply manure, composting material or compost to soil if:

- ▶ soil salinity is more than 4 deciSiemens per metre (dS/m) as measured by electrical conductivity using saturated paste extract analysis, based on a representative soil sample from the top 15 cm of soil. (AOPA Standards and Administration Regulation, Section 25)
- ▶ soil salinity will increase after manure is applied by more than 1 dS/m (same analysis method). (AOPA Standards and Administration Regulation, Section 25)
- ▶ soil nitrate-nitrogen levels in the top 60 cm will increase after manure is applied to a level that equals or exceeds the limits shown in Table 9.2.

You may apply above these levels if you can prove it will be beneficial to the soil.

TABLE 9.2

NITRATE-NITROGEN LIMITS FOR MANURE-APPLIED LANDS IN ALBERTA*

SOIL	SANDY SOILS (> 45% SAND AND WATER TABLE SHALLOWER THAN 4 M)	SANDY SOILS (> 45% SAND AND WATER TABLE DEEPER THAN 4 M)	MEDIUM- AND FINE- TEXTURED SOILS
Brown	80 kg/ha (75 lb/ac)	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)
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Irrigated	180 kg/ha (160 lb/ac)	225 kg/ha (200 lb/ac)	270 kg/ha (240 lb/ac)

* AOPA Standards and Administration Regulation, Schedule 3, Table 3.

Source: Alberta Agriculture, Food and Rural Development: 2002. Reference Guide: Agricultural Operation Practices Act. Alberta Agriculture, Food and Rural Development.

Soil Testing

Operators who apply over 500 tonnes of manure (wet weight) annually are required to perform soil tests and maintain nutrient management records. Soil testing must be conducted to ensure that nitrate-nitrogen limits are not exceeded. Testing must be done by a qualified lab in accordance with the most recent edition of the Canadian Society of Soil Science's *Manual on Soil Sampling and Methods of Analysis* (AOPA Standards and Administration Regulation, Schedule 3).



- ➡ People applying over 500 tonnes of manure annually must perform soil tests, but soil tests are a valuable tool for any crop producer.

Courtesy of AAFRD

Producers must regularly test for key soil characteristics on all manure-applied fields as follows (AOPA Standards and Administration Regulation, Schedule 3):

- ▶ Extractable nitrate-nitrogen and ammonium-nitrogen in the top 60 cm
- ▶ Soil salinity in the top 15 cm
- ▶ Soil texture – one-time analysis from soil depths 0-15 and 15-30 cm

For more about Nutrient Management Requirements, see *The Reference Guide: Agricultural Operation Practices Act* (AAFRD), a summary of AOPA's nutrient management requirements. Contact the nearest office of the Natural Resources Conservation Board (NRCB) for more information or visit the NRCB website (<http://www.nrcb.gov.ab.ca>).

Record Keeping

An owner or operator is required to keep nutrient management records for as long as that person owns the operation. All others receiving manure are required to keep records for five years (AOPA Standards and Administration Regulation, Section 28).

The requirements for record keeping depend on the amount of manure involved:

- ▶ A person who receives or removes 500 tonnes or more of manure per year must record:
 - the volume or weight of manure received or removed;
 - the name and address of the person from whom manure is received or removed; and
 - the date of the receipt or removal.
- ▶ A person who applies 500 tonnes or more of manure per year to land under the person's control must record:
 - the name and address of a person from whom manure is received, the date it was received, and the volume or weight received;
 - the legal description(s) of the field(s) receiving manure and the area of land to which manure is applied;
 - the volume or weight of the manure applied to each field;
 - the application rates of manure nutrients and fertilizer by field and year;
 - the dates of application and incorporation for each field and the method used; and
 - the soil test results by field for the nutrients specified in Schedule 3 (AOPA Standards and Administration Regulation).



→ AOPA specifies the types of records to be kept by people spreading manure.

Courtesy of AAFRD

For information on the regulations pertaining livestock operations and manure storage, refer to the livestock manuals in this *Beneficial Management Practices* series or contact the nearest NRCB office.

9.1.2 Environmental Protection and Enhancement Act

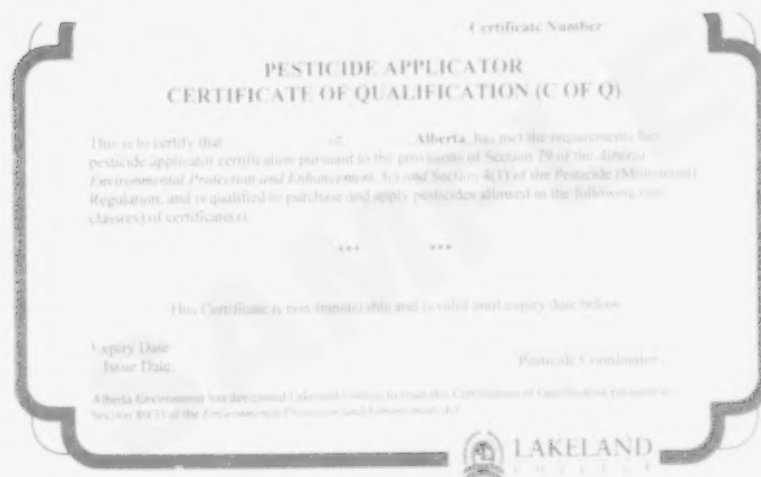
Pesticide Use

The EPEA regulates the sale, use, application, handling, storage, transport and disposal of pesticides. For example, the regulations of this Act specify:

- ▶ Use of pesticides according to the directions specified on the label.
- ▶ Transportation and disposal of pesticides in a way that ensures they will not contaminate food or water.
- ▶ Storage of pesticides in their original containers or in other containers that are clearly marked.
- ▶ Responsibility of the user for cleanup and decontamination in case of accidental spills.
- ▶ Washing of pesticide-contaminated material or sprayers is prohibited within 30 m of an open water body or on a public waterworks system.
- ▶ Pesticide storage is not allowed within 30 m of an open water body.
- ▶ No person shall use, apply handle, transport, store or dispose of a pesticide or operate any equipment involving the use, handling, transportation, storage handling or disposal of pesticides in a manner that is or is likely to cause an adverse effect.

There are also restrictions on the handling of pesticide application equipment. These include:

- ▶ The operator must be present at all times while filling the sprayer, and must maintain an air gap or have an operating back flow prevention device while filling the sprayer tank from a municipal waterworks system or from an open body of water.
- ▶ A Pesticide Applicator Certificate and Service Registration is required for commercial applicators.
- ▶ A Special Use Approval permit is required from Alberta Environment to apply or store pesticides or wash equipment used to apply pesticides in, on or within 30 m of an open body of water. This does not include sloughs or ponds less than 10 acres in area, providing they are completely surrounded by private land with no drainage off the land.
- ▶ Some pesticides have unique hazard characteristics and require the applicator to be knowledgeable to use them. Therefore producers must become certified to purchase and apply certain hazardous pesticides. This mandatory certification currently applies to: aluminium phosphide (Phostoxin, Gastoxin); picloram (Tordon 22 K); and triclopyr (Garlon).



Commercial pesticide applicators must be certified.

Source: Lakeland College

Pesticide applicator training courses are available at Fairview College (1-780-835-6617 or 1-888-999-7882), Lakeland College (1-866-853-8646), Olds College (1-800-661-6537 or 1-403-556-4684) and Lethbridge Community College (1-800-572-0103 or 1-403-320-3323).

Prohibited Releases

The *Environmental Protection and Enhancement Act* (EPEA) prohibits operators from releasing into the environment a substance in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect on the environment. While "significant" is not defined in EPEA, "adverse effect" is broadly defined to mean the "impairment of, or damage to, the environment, human health or safety or property." For example, if a farm operator spreads manure on land at a rate that will overload the nutrient levels in the soil, or releases manure on land where the manure will run into a water body, the operator is in violation of EPEA.

Alberta Environment can issue a substance release environmental protection order (EPO) when a substance release into the environment is causing, has caused or may cause an adverse effect. These EPOs can be issued even if an operation is in compliance with legislation, as they are intended to be remedial/preventive in nature rather than punitive. Generally these EPOs will direct an operator to develop a plan for dealing with the release and to implement the plan once it has been approved by Alberta Environment.

Alberta Environment can also issue an EPO to an individual responsible for the release of an offensive odour, to order that individual to, among other things, prevent, minimize or remedy the offensive odour or destroy the cause of the odour. This power does not apply to offensive odours from an agricultural operation that is carried on in accordance with "generally accepted practices" for that operation. However, there is no definition of "generally accepted practices." Whether an operator is following "generally accepted practices" will be decided by the Environmental Appeal Board or by a peer review board appointed by the Minister of Agriculture, Food and Rural Development.

Duty to Report

EPEA requires operators to report any releases that may cause an adverse effect on the environment. A release must be reported immediately once it has been discovered. Failure to report a release can result in significant fines. Calling Alberta Environment's emergency response line (1-800-222-6514) is usually sufficient to report a release. In some circumstances, an operator will also be required to file a subsequent written report.

Typically, when an operator reports a release, Alberta Environment will require the operator to identify the steps that the operator is taking to prevent harm to the environment and to prevent the release from reoccurring.

Liability of Directors and Officers

If a corporation violates EPEA, any officer, director or agent of the corporation who was involved with the incident, even in a minor way, could face prosecution under EPEA. This applies whether or not the corporation itself is prosecuted for the violation and regardless of whether the officer, director or agent works for a large corporation or simply a small incorporated family farm. This means an officer, director or agent of an incorporated farm is held personally responsible for EPEA violations, if the officer, director or agent directed or participated in the violation in any way.

Intent to Commit

The vast majority of offences under EPEA are "strict liability" offences. Unlike criminal offences, with strict liability offences, the courts are only concerned with whether the operator committed the offence, and not whether he or she intended to commit the offence or the morality of the operator's actions. If the operator did cause the impairment, the courts will convict the operator unless the operator can show that the action was in accordance with due diligence in running the operation and in carrying out the activity at issue (see Section 9.3 for more on due diligence). That is, if the operator can show that all reasonable steps were taken to prevent the contravention of EPEA, the operator will not be found guilty under EPEA.

For a small proportion of the offences under EPEA, the intent to commit the offence must also be proven to obtain a conviction. For those offences, the due diligence defence does not apply.

Fines

For strict liability offences, an individual is liable for a fine of not more than \$50,000 for each offence under EPEA and a corporation is liable for a fine of not more than \$500,000 for each offence under EPEA. Each day that a release or impairment occurs is treated as a separate offence. For example, a release from a catch basin occurring over two days would be treated as two offences and expose the corporation to a maximum fine of \$1 million.

Those offences that require proof of intent to commit the offence carry higher penalties: a \$100,000 maximum fine for individuals and a \$1 million maximum fine for corporations.

9.1.3 Soil Conservation Act

The *Soil Conservation Act* gives municipal councils the authority to protect land from soil loss or deterioration. Under the Act, each landholder has the responsibility to actively prevent soil loss or deterioration from taking place or, if soil loss or deterioration is already taking place, to stop it from continuing. Each municipal council has the duty to ensure that each landholder in its jurisdiction fulfils this responsibility.

When agricultural practices cause or are likely to cause soil degradation, a soil conservation officer, usually an agricultural fieldman acting on behalf of the municipality's agricultural services board, may serve notice on the landholder advising him or her to take remedial action within a specified time. The landholder may appeal this notice. If the appeal fails, then the landholder must comply with the notice.



— Landholders are required to actively prevent soil degradation.

Courtesy of AEP 903

If the remedial action is not done within the specified time, the soil conservation officer and/or others under the officer's direction may enter the property and perform the required work. The cost of this work may be collected by a tax on the property. Any person obstructing the officer or failing to comply with the notice is subject to a fine of up to \$5,000.

9.1.4 Water Act

The *Water Act* became law in January 1999. Approval from Alberta Environment is required for the undertaking of an activity that may:

- ▶ alter the flow or level of water,
- ▶ change the location or direction of flow of water,
- ▶ cause siltation of water,
- ▶ cause erosion of any bed or shore of a body of water, or
- ▶ cause an effect on the aquatic environment.

To find out if your planned project requires a licence, contact a water specialist at Alberta Agriculture, Food and Rural Development or Agriculture and Agri-Food Canada – PFRA.

9.1.5 Public Health Act

The *Public Health Act* gives regional health authorities significant powers to protect the public health. This Act has priority over all provincial statutes, except the Alberta Bill of Rights.

The *Public Health Act* allows a regional health authority, if it has reasonable and probable grounds to believe that a nuisance exists, to enter onto property to inspect the property, take samples of any substance or equipment being used, and perform tests at the property. The Act defines "nuisance" as: "a condition that is or that might become injurious or dangerous to the public health, or that might hinder in any manner the prevention or suppression of disease."

Thus, if a regional health authority becomes aware of a public health hazard at a farm, it can take steps to protect the public health and have the health hazard eliminated. In addition, if a farm operator contravenes the health authority's orders, the operator is liable to a fine of not more than \$100 for each day the contravention continues.

9.1.6 Weed Control Act

The *Weed Control Act* provides the legal authority to enforce weed control. It identifies three categories of weeds: restricted, noxious and nuisance. It mandates the eradication of restricted weeds and control of noxious and nuisance weeds.

9.1.7 Agricultural Pests Act

The *Agricultural Pests Act* is enabling legislation that provides the legal authority to deal with native and introduced pests (insects, vertebrate pests and plant diseases) that affect agricultural production.

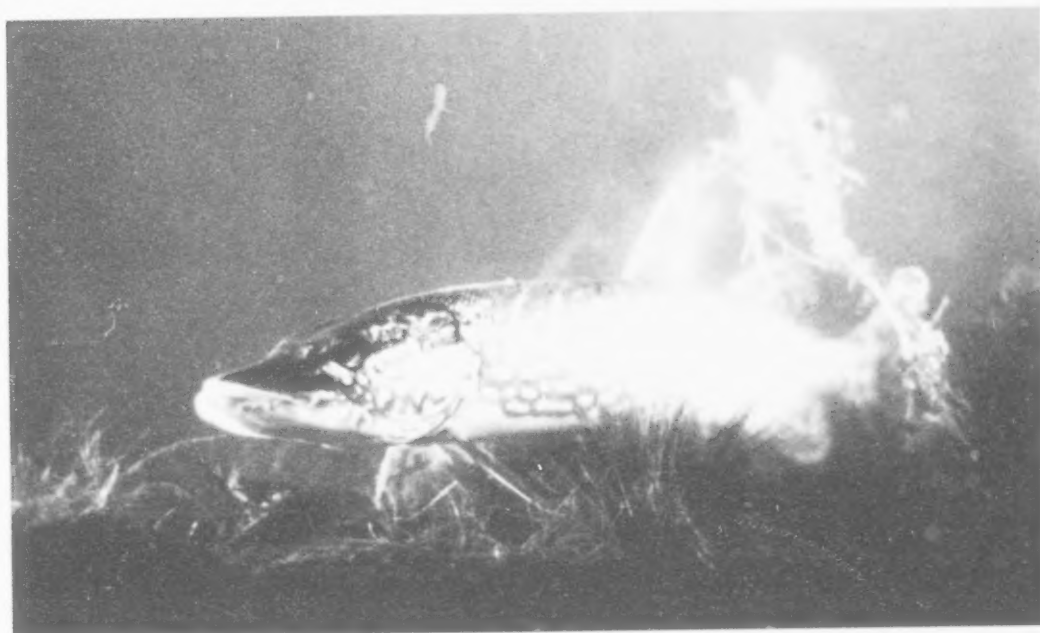
9.2 Federal Legislation

The two major acts relating to environmental impacts from cropping operations are the *Fisheries Act* and the *Pest Control Products Act*.

9.2.1 Fisheries Act

Deleterious Substance

The *Fisheries Act* prohibits anyone from depositing or permitting the deposit of anything into any type of water frequented by fish, which can have a "deleterious" or harmful effect on the fish. Further, the Act prohibits anybody from depositing a "deleterious" or harmful substance in any place under any condition where the substance *may* enter any water frequented by fish. The Act defines the phrase, "water frequented by fish" very broadly to include all internal waters of Canada. This definition includes any creek, river, stream, lake or slough frequented by fish, including a creek that has minnows in the spring, but dries up later in the summer.



➡ Fish habitat is protected by the federal Fisheries Act.

Courtesy of AAFRD

As an example, an operator commits an offence under the Act if he spreads manure on land near a stream frequented by fish and the manure gets into the stream in sufficient quantities to have a "deleterious effect." The offence results even if the manure does not actually cause harm to the fish. The mere fact that the manure reached water frequented by fish is an offence and may result in charges under this Act, unless the operator can prove that at all times, the water is not, has not been, and is not likely to be frequented by fish.

In addition, an operator risks committing an offence if he spreads manure on land near a stream frequented by fish, even if the manure does not in fact enter the water, but had a reasonable chance of entering the water. However, if the operator can prove that at all times, the water is not, has not been and is not likely to be frequented by fish, then the operator has not committed an offence under the Act.

Harmful Alteration, Disruption or Destruction of Fish Habitat

The *Fisheries Act* prohibits the carrying on of any work or undertaking that results in "harmful alteration, disruption or destruction" of fish habitat, although an authorization can be obtained from the Department of Fisheries and Oceans allowing such an activity. As noted above, fish habitat is defined quite broadly in the Act. These provisions may come into play in situations in which an operator would also require approval under Alberta's *Water Act* for a water management project.

Liability of Directors and Officers

If a corporation violates the Act, any officer, director or agent of the corporation who was involved with the incident, even in a minor way, is liable on conviction to punishment under the Act, whether or not the corporation itself has been charged. This is true regardless of whether the officer, director or agent works for a large corporation or a small incorporated family farm. This means an officer, director, agent or a incorporated farm can be held personally responsible for violations of the Act, if the officer or director directed or participated in the violation.

Strict Liability Offences

Offences under the *Fisheries Act* regarding the deposit of deleterious substances or harmful substances into water frequented by fish are strict liability offences. The courts are only concerned with whether the operator committed the offence, and not whether he or she intended to commit the offence or the morality of the actions.

If the operator did commit the "deleterious substance" activity, the courts will convict the operator unless the operator can show that:

- * at all times, the water is not, has not been and is not likely to be frequented by fish;
- * the operator acted with due diligence to prevent the commission of the activity at issue; or
- * the operator reasonably and honestly believed in the existence of the facts that, if true, the operator's conduct would be rendered innocent.

Fines

An individual or incorporated firm is liable to a fine not exceeding \$1,000,000 for the operator's first deleterious substance offence and to a fine not exceeding \$1,000,000 or to imprisonment for a term of not exceeding three years or to both for any subsequent deleterious substance offence.

9.2.2 Pest Control Products Act

The *Pest Control Products Act* specifies the responsibilities of the federal Pest Management Regulatory Agency (PMRA) for registration of pesticides for use in Canada.

In terms of user responsibility, as stated on the product label, anyone using a pest control product has the responsibility to read the label and follow the directions including the following:

- * before purchasing a pesticide, to determine if the product will control the pest problem and if it can be applied in a safe manner;
- * before mixing the pesticide with other products or additives, to ensure product compatibility;
- * before spraying, to determine the required precautions during spraying, and to follow those precautions.

9.3 Due Diligence

To avoid a conviction under EPEA and the *Fisheries Act*, an operator must have acted with due diligence in running the operation and in carrying out the activity at issue.

Whether an operator acted with due diligence is decided by the courts on a case-by-case basis. Generally, the courts have indicated that to act with due diligence, one "must take all reasonable steps to avoid harm. However, that does not mean [one] must take all conceivable steps".² In addition, the courts have established that, "reasonable care and due diligence do not mean superhuman efforts. They mean a high standard of awareness and decisive, prompt and continuing action".³ In considering whether an accused acted with due diligence, the courts, "...examine what was done, what controls were in place, what was the state of technology that existed through the evidence of lay and expert witnesses to determine if the accused acted reasonably in the circumstances".⁴

R. v. British Columbia Hydro and Power Authority [1997] B.C.J. No. 1744, paragraph 55.

R. v. Courtaulds Fibres Canada (1992), 9 C.T.R. (N.S.) 304 at 313 (Ont. Prov. Ct.).

R. v. Northwood Pulp and Paper (1992) 9, C.T.R. (N.S.) 289 at p. 293.

Some of the things a court may examine in determining whether environmental due diligence has been exercised are:

- ▶ Did the farm operator establish and monitor pollution prevention system? For example, is there a reasonable nutrient management plan for the operation?
- ▶ Did the operator ensure that he instructed employees to:
 - set up the pollution prevention system so the operation complies with the industry practices and environmental laws, and
 - report to the manager if the operator was not complying with the system? For example, if soil-testing analysis indicated high nitrate levels, making it dangerous to apply more manure, was the manager told?
- ▶ Was the operator aware of the industry standards regarding environmental pollutants and risks?
- ▶ Did the operator address problems immediately and in a timely fashion?

In addition, a court may examine whether a corporation has an environmental management system, what the environmental management system contains, how detailed it is, and whether it is followed by the corporation, to determine whether the corporation acted with due diligence in carrying out the activity in question.

Environmental Management Systems

Environmental management systems are used by corporations to establish and implement policies and procedures for operating an environmentally sustainable business. An environmental management system examines the corporation's operations:

- ▶ to determine how these operations impact the environment,
- ▶ what policies and procedures can be implemented to lessen or eliminate the operation's environmental impacts,
- ▶ what environmental standards and laws the corporation must follow, and
- ▶ whether the corporation is following these standards and laws.

The environmental management system will then put into place the policies and procedures to reduce the operation's environmental impacts and to properly train its employees to meet and maintain the applicable environmental standards and laws. Finally, an environmental management system will provide for a periodic re-evaluation of these environmental policies and procedures.

A farm operator who develops an **environmental farm plan** is taking the first steps toward developing an environmental management system. For more information on Alberta's Environmental Farm Plan (EFP) program, call toll-free 1-866-844-AEFP (2337), or visit the EFP website (www.albertaeefp.com).

¹ R. v. Bata Industries Ltd. [1992] O.J. No. 236 at page 24 - 25 (Ont. Prov. Div.) online: QJ (O.J.), rev'd in part on other grounds 14 O.R. (3d) 354, rev'd in part on other grounds 127 D.L.R. (4th) 438.

9.4 Information Sources

9.4.1 Contacts

All Alberta Government offices may be reached toll-free by dialing 310-0000.

- ▶ Natural Resources Conservation Board regional offices: Lethbridge (403-381-5166), Barrhead (780-674-8303), Red Deer (403-340-5241), or Fairview (780-835-7111); website: <http://www.nrcb.gov.ab.ca>
- ▶ Alberta Agriculture, Food and Rural Development: Ag-Info Call Centre, phone: 1-866-882-7677; website: <http://www.agric.gov.ab.ca>
- ▶ Your district office of Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada.
- ▶ Alberta Environment's Environmental Response Centre: phone: 1-800-222-6514. You can call the Centre to report the release of a substance that is causing, has caused or may cause an adverse effect on the environment, or to get information on handling any type of spill.
- ▶ Queen's Printer: phone: 1-780-427-4952 (dial 310-0000 for a toll-free call); website: <http://www.qp.gov.ab.ca>
- ▶ Environmental Law Centre: phone: 1-800-661-4238; website: <http://www.elc.ab.ca/home/index.cfm>

9.4.2 References

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Glossary

These definitions apply to how these words are used in this manual.

Adsorption

A measure of the degree to which a substance binds to particles.

Agro-ecosystems

Ecosystems that are used for agriculture.

Algal bloom

A large, visible mass of algae found in surface water bodies.

Anti-siphon valve

A valve installed to prevent fuel loss due to gravity.

Backflow

The unwanted reverse flow of liquids in a piping system.

Balanced fertility

Calculating and applying the appropriate amount of each nutrient needed by a crop.

Ballasting

Adding (or removing) weight from a tractor to balance axle weight distribution.

Banding

Placing fertilizer below the soil surface in a narrow band, usually at planting time, with the band close to the seed.

Beneficial management practices (BMPs)

Practices that benefit the environment while meeting or exceeding legal requirements and being practical for producers to do.

Bioconcentration

Accumulation of a persistent substance in the tissue of an organism.

Biodiversity

Biological diversity; the variety of living organisms, ecosystems and ecological processes.

Biological control

The use of natural agents, such as birds, insects, mammals or fungi, to control pests.

Biomagnification

Cumulative increase in the concentration and toxicity of a persistent substance in successively higher levels of the food chain.

Bollards

A barrier constructed of a sturdy material, such as steel piping filled with cement, set up close to fuel tanks to guard against collision damage.

Buffer zone

An area of land adjacent to a riparian area that is developed or conserved to reduce erosion, intercept contaminations and provide wildlife habitat. The buffer zone is usually left in permanent vegetation.

Carbon sequestration

Carbon storage; the transfer of carbon dioxide from the atmosphere into another carbon-based substance.

Chemfallow

Chemical fallow; a summerfallow system in which herbicides alone are used to control weeds.

Closed handling system

A system for transferring fertilizers or other chemicals directly from the storage container to the applicator equipment, so humans and the environment are never exposed to the chemicals.

Coarse-textured soil

Soil containing more than 50% sand and less than 20% clay.

Collection system

A method of gathering liquid into a single contained spot to prevent runoff and contamination of water sources.

Commercial fertilizer

Fertilizer manufactured from non-renewable resources.

Conservation fallow

A broad term for summerfallow systems that maintain plant residues on the soil surface to reduce soil erosion, while still providing weed control and soil moisture conservation. Herbicides or a combination of herbicides and tillage is used to control weeds.

Conservation tillage

A broad term for any type of tillage system that leaves 30% or more of the soil surface covered with crop residue after planting.

Contamination

Alteration of a material by the introduction of a chemical or other substance that makes the material unfit for a specified use.

Continuous cropping

A cropping system in which crops are grown every year with no fallow years in between.

Conventional fallow

A summerfallow system in which the fallow field is tilled frequently.

Conventional tillage

A tillage system that uses multiple tillage passes for weed control, fertilizer application, seed bed preparation and seeding.

Cover crop

A crop planted outside of the normal growing season specifically for soil cover rather than for harvest. These crops are planted to reduce soil erosion and may help reduce leaching of nutrients to the groundwater.

Crop residues

Plant material remaining after harvest, which includes stubble, leaves, straw, roots and plant seeds.

Crusting

A surface layer of hardened soil that forms a barrier to water and air infiltration when wet. On drying, the layer is more compacted and brittle than the soil beneath it. Crusting makes it harder for plants to emerge and may also increase runoff.

Direct seeding

A system that sows seed directly into the stubble of last season's crop. The soil is not tilled in the spring before planting. Crop residues remain on the soil surface, with at least 50% of the stubble upright and anchored.

Discharge area

An area where groundwater comes to the soil surface. If the groundwater is saline, a saline seep can form in the discharge area.

Drop structures

Structures constructed along waterways to drop water to lower elevations without causing erosion.

Economic threshold

The number of pests in a given crop unit sufficient to cause crop loss greater than the cost of control.

Ecosystem

A system of living organisms interacting with each other and their environment, linked together by energy flows and material cycling.

Electrical conductivity (EC)

A measurement of the flow of electricity through a material, such as water or a soil solution. It can be used as a measure of the soluble salt content of soil, because the more salts in the soil sample, the greater its electrical conductivity.

Environmental farm plan

A risk-based, self-assessment checklist that producers use to identify management practices on their operation that may affect the environment. They use the results of their assessment to develop an action plan to address areas of concern.

Environmentally sensitive areas

Areas that are especially sensitive to contamination, such as, streams, rivers, lakes, water wells, dugouts, shelterbelts, and neighbours' yards.

Erosion

See Soil erosion.

Field shelterbelt

A barrier of trees or shrubs used to shelter agricultural fields.

Fine-textured soil

Soil containing more than 40% clay.

Flushing bar

An aluminum bar with chains or belts hanging from it. The bar is attached to the front of a tractor during haying to scare wildlife out of the way of the equipment.

Fragmentation

A process by which habitats are increasingly subdivided into smaller units, resulting in the increased isolation of the individual units as well as loss of total habitat area.

Gear up – throttle down

A driving technique used to reduce a tractor's use of fuel. The driver reduces the engine speed and shifts up a gear to maintain the same ground speed.

Grassed waterway

A broad, shallow channel with a permanent grass cover, which is designed to carry water without causing soil erosion.

Green manuring

The practice of growing a short-term crop during a summerfallow period to improve soil tilth, add organic matter and nutrient, to the soil and provide soil cover. After eight to 10 weeks of growth, the green manure crop is worked into the soil, desiccated with herbicides, or hayed to allow soil moisture recharge for the following year's crop.

Greenhouse gases

Gases in the atmosphere that trap some of the heat transmitted by the Earth towards space. Greenhouse gases include water vapour, carbon dioxide, ozone, methane, nitrous oxide and chlorofluorocarbons.

Groundwater

Water found below the ground surface. This water is free to move by gravity, soaking into the ground from wetlands, lakes or precipitation. The upper surface of the groundwater forms the water table.

Gully

A large eroded channel formed in the soil as a result of water runoff.

Habitat

The environment in which a plant or animal lives.

Hardpan

A hardened soil layer in the lower A or B horizon.

Ignition sources

Anything that causes sparks or high heat that could start a fire (e.g. smoking, running an engine, lightning).

Impermeable

Resistant to penetration of moisture.

Infiltration

The downward flow of water from the land surface into and through the upper soil layers.

Inorganic fertilizer

See Commercial fertilizer.

Integrated pest management (IPM)

A method of pest control that combines mechanical, chemical, biological and cultural means to minimize pest infestations and their impacts.

Interflow

The lateral movement of water in the zone between the soil surface and the water table during and immediately after a precipitation event. Interflow water discharges directly into a surface water body.

Leaching

The removal of soluble substances by water percolating through the soil down to the water table.

Lined channel

A means of dropping water to lower elevations along steep parts of a waterway.

Licensed landfill

A place designed to dispose of solid waste safely. All licensed landfill sites must have approval from Alberta Environment.

Marginal crop land

Land with characteristics that severely limit annual crop production.

Medium-textured soil

Soil containing less than 50% sand and less than 40% clay.

Mycorrhiza

A type of soil fungus that forms a win-win partnership with plants, substantially benefiting most agricultural crops. Frequent tillage, fallowed fields and broad-spectrum fungicides often reduce mycorrhizal association.

Nitrate

A form of nitrogen that can be absorbed by plants and contribute to growth. Nitrate may come from organic or inorganic sources. Because nitrate is not attracted to soil particles, it can readily move past the root zone of most plants and into groundwater.

Non-target organism

See Target pests.

Nutrient

A substance that provides nourishment for the maintenance of life and growth of plants or animals.

Nutrient management planning

an approach to nutrient management that aims to optimize crop yield and quality, minimize fertilizer input costs, and protect soil and water.

Organic fertilizer

Fertilizer from organic sources, including manure, compost, decaying plant matter and sewage sludge.

Organic matter

See Soil organic matter.

Overgrazing

Repeated grazing of plants before a sufficient rest or growth recovery period has elapsed. Overgrazing results in a reduction of long-term forage productivity and a deterioration of range condition. It can also result in increased weeds and invasive plant species.

Overland flow

The flow of water over a land surface due to direct precipitation. Overland flow generally occurs when the precipitation rate exceeds the infiltration capacity of the soils.

Overpack

Put a smaller container into a larger container, so the larger container can catch any leaks from the small container.

Parasite

An organism that lives in or on another organism and benefits by deriving nutrients at the other's expense.

Pathogen

A bacterium, virus or other microorganism that can cause disease.

Perennial forages

Grasses and legumes that grow each spring from plants grown in previous year(s).

Permanent cover

Perennial plant cover that protects the soil throughout the year, year after year.

Pesticide

A general name for substances used to control pests such as insects, rodents, fungal diseases or weeds. The term includes insecticides, rodenticides, fungicides, and herbicides.

Pesticide resistance

See Resistance, pesticide.

pH

The degree of acidity or alkalinity of a soil, expressed as a measure of free hydrogen ion activity in the soil.

Pore space

The space between particles in the soil, occupied by air or water.

Precision farming

See Site-specific farming.

Pressure rinse

A method to properly rinse pesticide containers. Water is sprayed under high pressure against all inside surfaces of the container and the rinsate is added to the sprayed tank.

Recharge area

An area where water moves through soil and reaches groundwater.

Reduced tillage

A tillage system using only one or two tillage passes prior to seeding (e.g. one pass in the fall and one in the spring).

Resistance, pesticide

A build-up of tolerance to a pesticide, usually due to overuse or to appropriate use over an extended period.

Rinsate

Wastewater from cleaning the inside of product containers or chemical application equipment.

Riparian areas

Lands adjacent to streams, rivers, lakes and wetlands, where the vegetation and soils are strongly influenced by the presence of water.

Run-on

Water that flows onto a given area.

Runoff

Water that moves across the land as overland flow or that moves laterally in an unsaturated zone as interflow.

Saline seep

A groundwater discharge area where salts have gradually accumulated.

Saline soil

A soil containing a high enough concentration of soluble salts to interfere with crop growth.

Secondary containment

Any structure, such as a dike, built around a chemical storage area to reduce the amount of material that could reach soil or water in the event of a spill or leak.

Sediments

Soil particles carried by runoff and deposited in water bodies.

Shelterbelt

A barrier of trees or shrubs planted to provide protection from the weather.

Site-specific farming

The practice of tailoring farm inputs according to differences in conditions within a farm field. Also called precision farming.

Slope steepness

Slope steepness can be expressed in several ways. As a percentage, it is calculated as the (vertical rise/horizontal distance) x 100. As a ratio, it is expressed as the horizontal distance : vertical rise. Thus, if a slope rises 1 m for every 20 m of horizontal distance, the per cent slope is 5% and the slope ratio is 20:1.

Soil aggregate

Many soil particles held together in a single, stable mass.

Soil compaction

The loss of pore space due to equipment and animal traffic. Compaction makes it difficult for water, air and roots to move through the soil.

Soil erosion

The movement of soil particles due to wind, water or tillage.

Soil organic matter

The part of the soil that consists of plant and animal residues in various stages of breakdown or decomposition.

Soil structure

The manner in which soil particles stick together. A soil with many small aggregates or clumps, lots of pore space and no crust, has good structure.

Soil texture

The composition of soil described by its proportion of clay, sand and silt-sized particles.

Solubility

A measure of the degree to which a substance can dissolve in a solvent.

Strip cropping

The practice of alternating strips of crops with strips of fallow to reduce erosion.

Strip harvesting

The practice of leaving strips of crop standing when harvesting. This provides a habitat for insect pests to avoid them moving to an adjacent crop and causing more damage. It also provides habitat for natural enemies to maintain their populations. This will also trap snow and improve soil moisture.

Summerfallow

The practice of leaving a field without crop growth for a growing season, using herbicides and/or tillage to control weeds. The term is often used to describe one particular type of summerfallow: conventional fallow.

Surface water

All water found on the ground surface, such as lakes, ponds, sloughs, wetlands, dugouts, rivers, creeks, temporary streams, canals and drainage ditches. (Compare to Groundwater.)

Sustainable

Practices that provide a flow of goods and/or services over a long period of time without degrading the environment or lowering productivity.

Target pests

Pests that a pesticide is specifically designed to control. Anything else affected by the pesticide is a non-target organism.

Temperature inversion

When warmer air lies above cooler air near the earth's surface.

Trap strips

Strip of a crop seeded around the outside of another crop to attract and trap insects for selective control.

Triple rinse

A way to properly rinse chemical product containers. To triple rinse a pesticide container, fill it 10% full of water or other dilutant, cap tightly, and shake the container. Then add the rinsate to the spray tank. Repeat two more times, using fresh water or dilutant for each rinse.

Volatility

A measure of the degree to which a substance can evaporate or be vaporized.

Water body

Any location where water is present. Water bodies include rivers, streams, wetlands, aquifers and sloughs.

Water table

The top of the water-saturated zone in the soil (where all spaces between soil particles are filled with water).

Waterway

A low path where surface water collects and flows.

Wetland

A low-lying area that tends to be covered by water frequently enough to support aquatic plants and wildlife, at least in some years.

Zero tillage

A cropping system in which seeding is the only operation that disturbs the soil. Less than 40% of the soil surface is disturbed during seeding.

Abbreviations and Conversions**Nutrient Abbreviations**

- ▶ Phosphorus is elemental P
- ▶ Phosphate is P_2O_5
- ▶ Potassium is elemental K
- ▶ Potash is K_2O
- ▶ Nitrogen is N
- ▶ Organic nitrogen is organic N = total N - inorganic N (or ammonium N)
- ▶ Total nitrogen is total N = organic N + inorganic N
- ▶ Inorganic N (also called mineral or plant-available N) is ammonium N and nitrate N. Most of the inorganic N in manure is ammonium form

Unit Abbreviations and Conversions

- ▶ 1 kilogram (kg) = 1000 milligrams (mg) = 2,205 pounds (lb) = 35.28 ounces
- ▶ 1 kilometre (km) = 1000 metres (m) = 3,281 feet (ft) = 39,370 inches (in) = 0.6214 miles
- ▶ 1 m³ = 1000 litres (L) = 220 gallons (Imperial) = 264.2 gallons (U.S.)
- ▶ 1 hectare (ha) = 10,000 m² = 107,639 ft² = 2.471 acres (ac)
- ▶ to convert lb/ac to kg/ha multiply by 1.12 (therefore 1 lb/ac = 1.12 kg/ha)
- ▶ to convert kg/ha to lb/ac multiply by 0.893 (therefore 1 kg/ha = 0.893 lb/ac)
- ▶ 1 tonne = 1000 kg = 2,205 lb = 1.1025 ton (short)
- ▶ 1% = 110 kg/tonne = 10,000 mg/kg = 10,000 parts per million (ppm)
- ▶ 1 ppm = 1 mg/kg (solid) or 1 mg/L (liquid)
- ▶ 1 lb (or kg) of P = 2.29 lb (or kg) of P_2O_5
- ▶ 1 lb (or kg) of K = 1.2 lb (or kg) of K_2O
- ▶ to convert from ppm to lb/ac or kg/ha, the generally accepted procedure is to multiply by a factor of 2 for each 6-in (15-cm) depth of mineral soil or by 4 for each 12-in (30-cm) depth of soil
- ▶ bu = bushels
- ▶ cm = centimetres
- ▶ dS/m = deciSiemens per metre

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